THIRTEENTH ANNUAL REPORT

of

Pasture Research

In the

Northeastern United States
State College, Pennsylvania

1949

1949

Thirteenth Annual Report

of

Pasture Research

in the

Northeastern United States

U. S. Regional Pasture Research Laboratory
State College, Pennsylvania

Division of Forage Crops and Diseases
Division of Soil, Management and Irrigation
Bureau of Plant Industry, Soils, and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture
and
The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

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Copies of this report were sent to all organizations involved in the development of the present pasture research program in the twelve Northeastern States and in addition one copy to the Director of each of the following State Agricultural Experiment Stations -- Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Carolina, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, Virginia, and Wisconsin; three copies to Canada as follows-- Dean of Agriculture, University of Saskatchewan, Saskatoon, and Dominion Agrostologist and Main Library, Department of Agriculture, Ottawa; and one copy to each of the following-- The Library, School of Agriculture, Cambridge, England; Director of the Welsh Plant Breeding Station, Aberystwyth, Wales; Director of the Swedish Seed Growers Association, Svälof, Sweden; Library of the R. Agriculture, College of Sweden, Uppsala 7, Sweden; The Agricultural College of Norway, Vollebekk, Norway; Director of the Waite Agricultural Research Institute, Adelaide, Australia; Librarian, Division of Plant Industry, Council for Scientific and Industrial Research, Canberra City, A. C. T., Australia; Director, Grasslands Division, Palmerston North, New Zealand.

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This annual report of pasture research in the twelve Northeastern States is a progress report and as such may contain statements which may or may not be verified by subsequent experiments. The fact that any statement has been made herein does not necessarily constitute publication. For this reason citation to particular statements in the Report should not be published unless permission has been granted.

The Report is prepared primarily for the official use of forage crop research workers in the Region and since it is mimeographed in limited numbers it is not available for general distribution to individuals outside the Region.

D. TABLE OF CONTENTS

Page

Introduction 1

Part I

Cooperative research 3
Regional Project NE-10 "Management, breeding and utilization of forage crops adapted to the Northeast" 3
For the Maryland Experiment Station 4
For the Cornell Agricultural Experiment Station 5
For the Pennsylvania Agricultural Experiment Station . . . 5
Strain testing in Pennsylvania 5
For the Pennsylvania Agricultural Experiment Station . . 5
For the West Virginia Agricultural Experiment Station . . 6
Bromus inermis breeding (with Pennsylvania) 6
Dactylis glomerata breeding 7
At College Park, Maryland 7
At State College, Pennsylvania (Experiment Station) 7
At Beltsville, Maryland 9
At State College, Pennsylvania (Pasture Research Laboratory) 10
Phalaris arundinacea breeding (with Pennsylvania) 10
Phleum pratense breeding (with New Hampshire and Pennsylvania) 11
Poa pratensis breeding 11
At Morgantown, West Virginia 11
At State College, Pennsylvania 11
Lotus corniculatus breeding (with Pennsylvania) 12
Medicago sativa breeding 12
At NewBrunswick, N.J. 13
At Ithaca, Churchville, Tully and 4 regional test plots, New York 13
At State College, Pennsylvania (Experiment Station) 17
At Kingston, Rhode Island 18
At Beltsville, Maryland 18
At State College, Pennsylvania (Pasture Research Laboratory) 19
Trifolium pratense breeding 19
At Durham, New Hampshire 19
At State College, Pennsylvania (Experiment Station) 19
At State College, Pennsylvania (Pasture Research Laboratory) 20
Trifolium repens breeding 23
At Durham, New Hampshire 23
At New Brunswick, New Jersey 23
At State College, Pennsylvania (Pasture Research Laboratory) 23
Nutrition studies 25
Chemical composition of the pasture grasses . . . . . 25 (with New Hampshire)
Measurement of the nutritive value of pastures and of pasture plants (with Pennsylvania) 26
Pasture management experiments 28
Evaluation of grasses and legumes for hay, grass silage and pasture for dairy cattle (with Pennsylvania) 28
Grassland renovation trials in Connecticut (with Storrs, Connecticut) 29

Pasture renovation experiments 30
Date of seeding legumes, grasses, and weeds 30
At Burlington, Vermont 30
At State College, Pennsylvania 31
Evaluation of grasses and legumes for hay, silage, and pasture (with Pennsylvania) 31
Maintenance of legumes (With Cornell-New York, Maryland, New Jersey, New Hampshire, Pennsylvania, Storrs-Connecticut, and the Division of Soil Management and Irrigation 33
The relation of soil properties to the persistence of perennial legumes 33
Runoff from permanent pastures in Pennsylvania 34
(with Pennsylvania)
Soil fertility and soil moisture in grasslands (with Delaware, Maine, New Jersey and Rhode Island) 36

Part II

Research at the Laboratory 39
Cytogenetics and breeding 39
Varietal improvement in Dactylis glomerata and Trifolium repens 39
Inbreeding in orchard grass 39
Comparison of clonal, polycross and single cross progeny tests for the evaluation of individual plants of Dactylis glomerata . . . 40
Selection for persistency in Trifolium repens 40
Isolation of Ladino clover plants resistant to Sclerotinia trifoliorum 41
Genetic investigations 41
Inheritance of maturity in Dactylis glomerata 41
Inheritance of quantitative characters at the diploid and tetraploid levels in Dactylis spp. . . . 42
Inheritance of male sterility in Dactylis glomerata . . 42
Inheritance of anther color in Dactylis glomerata . . . 43
Inheritance of immunity from crown rust in diploid Festuca elatior 43
Inheritance of leaf coloration in Trifolium repens . . 43
Inheritance of flower color in Medicago sativa 43
Cytological investigations 44
Origin of aneuploidy in Dactylis glomerata 44
Polycross tests of hexaploid Dactylis glomerata 44
Hybridization of Lolium perenne by Festuca elatior . . 44
Interspecific relationships in Bromus spp. 44
Interspecific and intergeneric hybridization in the Leguminosae 45
Pathology 46
Studies with Sclerotinia Trifoliorum 46
Degeneration in S. Trifoliorum 46
The longevity and virulence of Sclerotinia Trifoliorum inoculum prepared from cultures grown on grain 47
Field tests 47

Physiology and biochemistry of pasture plants 49
Growth responses of Ladino clover clones under low light intensities 49
Plant climate studies 50
Relationship between time of orchard grass flowering in the field and the length of day 51
Effects of isopropyl N-phenyl carbamate on inhibiting head formation of orchard grass 51
The responses of Dactylis glomerata-Trifolium repens to nitrogen fertilization, soil moisture, and clipping treatments 52
Rate and frequency of potash applications on Dactylis glomerata-Trifolium repens 52

Part III

Pasture research at state stations 53
Connecticut (Storrs) 53
Alfalfa experiments 53
The maintenance and improvement of pastures 53
Maine 54
Evaluation of forage plants, clones, lines, varieties and hybrids developed by plant breeding 54
Management practices as they affect the productivity and persistence of Ladino clover-grass associations 55
Maryland 55
Orchard grass and bromegrass for forage with legumes . . 55
Red clover breeding 55
Red clover management to maintain stands 56
Alfalfa variety tests 57
Pasture renovation studies 57
Massachusetts 58
Yield and mineral composition of forage crops as influenced by soils and soil treatments 58
New Hampshire 59
The fertility needs of Ladino clover 59
The influence of pasture irrigation under New Hampshire conditions 60
Maximum use of roughage in feeding dairy cattle 61
Analysis of forage samples 62
New Jersey 62
Belle Ellen pasture experiment 62
Studies of reed canary grass for pasture and hay 63
The utilization of potash and nitrogen by Ladino clover under grazing conditions 63
The utilization of pastures in the production of pork . . 64
All roughage and pasture feeding experiments with dairy cattle 64
Small grains for fall and spring pasture 64

New Jersey (continued)
Winterkilling studies with Ladino clover 65
Utilization of pastures in the production of beef . . . 66
Supplemental irrigation on pasture 66
Rate of fertilization study with pastures in New Jersey 67
All roughage and pasture feeding experiments with dairy cattle 68
New York (Cornell) 68
Breeding and cytogenetic investigations with the forage plants of New York 68
Strain testing and breeding of forage plants for New York state and vicinity with special emphasis on problems of production during periods of midsummer drouth 71
Some factors affecting the seedling establishment of forage legumes 72
Studies of birdsfoot trefoil as a forage legume in New York 72
The effect of seeding rates, fertilizer application, and management in forage mixtures on the survival and productivity of alfalfa under various New York environments 73
The effect of stage of growth upon the (1) yield as hay and pasture (2) longevity of stand and (3) nutritional value of the principal forage grasses and legumes 73
The effect of feeding dairy cows certain fungicides used to prevent mold growth in hay on the production and quality of milk 74
The relationship of milk production to herbage characteristics from permanent and rotation pasture mixtures 74
Factors which influence the longevity, seasonal growth and productivity of Ladino clover 75
Clover root borer investigations 75
Alfalfa snout beetle investigations 76
European chafer studies 76
White grub investigations 77
Resistance of alfalfa to insects 78
Rhode Island 78
The response of strains and mixtures of forage plants to grazing 78
Vermont 79
Cytogenetics and breeding investigations with forage legumes 79
West Virginia 81
Pasture fertilization experiments 81
Maintaining profitable stands of alfalfa 81
Cause and remedy for red clover failure in West Virginia 81
Selection and breeding of red clover 82

List of publications 83

REPORT

OF

PASTURE RESEARCH

IN THE

TWELVE NORTHEASTERN STATES

FOR THE CALENDAR YEAR 1949

INTRODUCTION

It is becoming more and more evident that the results of forage crop research in the Northeastern Region are finding practical expression on farms. Such educational devices as Green Pasture Contests have dramatized the progress in grassland management that has been made in the last decade. An increasing number of farmers in the Region, particularly dairy farmers, realize the importance of grasses and legumes in the farm economy and with this realization has come a desire for more information. Then too, as forage crops become more intensively cultivated, new problems arise. For example, ten years ago Ladino clover was accepted as the almost perfect pasture legume for the Northeast, whereas today it is known to have limitations which under some conditions may seriously hamper its usefulness.

Research and extension specialists have reason to feel gratified with the progress that has been made in grass farming in the Region, but there is still much to accomplish both in research and in interpreting and adapting the results of research for use on individual farms. The importance of adequate fertilization and diversification in forage crops grown in order to provide nutritious feed - pasture, hay and silage - throughout the year, is widely recognized but the approach to developing an effective plan on any given farm is yet too empirical.

Maintenance of legumes in a mixed sward, economical preservation of forage in a nutritious condition, extent to which forage may be substituted for the more expensive concentrates in the animal diet, and provision of a continuous sequence of nutritious herbage throughout the grazing season are a few of the problems only partially solved. In recent years the possible damage to forage plants caused by diseases and insect pests has become more generally recognized. A cooperative attack by plant and animal scientists continues to be the most promising approach to the solution of these problems.

Present research at the Laboratory is definitely oriented toward the solution of basic pasture problems of regional interest. Practically all of the applied research in which the Laboratory was so heavily engaged during the war period has been completed or discontinued.

The organization of this Thirteenth Annual Report of pasture research in the twelve Northeastern States is similar to that of its immediate predecessors. Brief accounts of progress in research are given in Part I on cooperative projects, in Part II on Laboratory projects, and in Part III on State projects. A list of publications originating in the Region is appended.

A number of changes in personnel occurred at the Laboratory during 1949. W. M. Myers, who was in charge of Cytogenetics and Breeding, resigned to become Head of the Division of Forage Crops and Diseases, U.S.D.A. Mr. Angus A. Hanson, formerly of MacDonald College, McGill University, was appointed to fill the vacancy. Other resignations included Mrs. Sarah Riden, Miss Katherine Kovalenko (Mrs. James Trego), and Mrs. Mildred Baustian. Mrs. Patricia A. Altieri, John Felty and part-time agents, Donald Oldemeyer and J. Henry Horton were added to the technical staff. Miss Ellen Poorman was appointed as a secretary.

A collaborators' meeting with about 65 persons in attendance was held June 9 and 10, 1949, at State College, Pennsylvania. Other meetings during the year of interest to forage crop investigators were a conference held May 2 in New York City by the Northeastern Forage Crops Technical Committee to develop a project for regional strain testing of forage crops to be supported in part by Research and Marketing 9B3 funds, a meeting of the Eastern Alfalfa Improvement Group held August 8 and 9 at New Brunswick, New Jersey and a meeting of the Northeastern Soil Research Committee held March 29 and 30 also at New Brunswick. Detailed accounts of all these meetings were mimeographed and distributed by the respective groups concerned.

PART I

COOPERATIVE RESEARCH

Title: Regional Project NE-10 "Management, Breeding and Utilization of Forage Crops Adapted to the Northeast".

Leader: H. R. Albrecht, Chairman Technical Committee

Summary of Work Accomplished from June 30, 1949 to January 31, 1950:

The Technical Committee inaugurated a program of regional evaluation of forage species and strains to determine their adaptation in the 12 northeastern states with consideration given to certain factors of management.

Sub-Project 1, "The Evaluation of Forage Crops, Varieties and strains or their Use and Adaptation in the Northeast" was initiated after the project was approved during the summer of 1949. The Northeastern Region was divided into 7 sub-regions in each of which Ladino clover, birdsfoot trefoil, alfalfa, red clover, orchard grass, bromegrass and timothy were to be tested. Both new strains and established varieties are included in experiments. The following 4 of the 7 were planted in the fall of 1949:

Pennsylvania serving central and western Pennsylvania
Maryland serving central and eastern Maryland, southern New Jersey, southeastern Pennsylvania, Delaware
New Jersey serving northern New Jersey, northeastern Pennsylvania, southeastern New York
West Virginia serving West Virginia, western Maryland, southwestern Pennsylvania

The seed was assembled at State College, Pennsylvania and distributed to the 7 sub-regions by the holder of the Regional Trust Fund, the Department of Agronomy of the Pennsylvania State College. Arrangements were also made by the Chairman of the Technical Committee for multiplication of breeding material developed or brought into the region in order that such material can be evaluated generally throughout the region in uniform trials in comparison with old and new established varieties. These increases have been started at the following locations:

Cornell - Bromegrass
Pennsylvania - Orchard grass
New Jersey - Red clover
Maryland - Ladino clover
Pennsylvania (by agreement with the Nebraska Station) - Alfalfa

It is possible that some of these such as the orchard grass and the Ladino clover clones will be ready for testing during 1950.

Work planned for the fiscal year July 1, 1950 to June 30, 1951:

In the spring of 1950 uniform trials in the 3 remaining sub-regions will be planted at: Vermont serving Maine, New Hampshire, Vermont and Northeastern New York; Rhode Island serving Rhode Island, Massachusetts and Connecticut; and New York serving central and western New York. These tests like the 4 which were planted in the fall of 1950 will be subjected to 3 management practices:

1 - Clipping to simulate rotational grazing or silage
2 - First crop for hay or silage followed by clipping to simulate aftermath grazing
3 - Hay or silage from all cuttings made during the season.

The first harvests of the several forage species and varieties under the three different management treatments will be made during this period. In addition to yield data, factors such as insect and disease incidence, hardiness, initiation of growth in spring, flowering date, harvest date and other data will be assembled. Information will also be obtained regarding the environment to which the plants were subjected during the course of the experiment. As minimum requirements rainfall, temperature, relative humidity, soil moisture, wind velocity will be included if at all possible. Other observational records will include such general items as snow cover, late frosts in spring, early frosts in fall, heaving, ice sheets, rainfall, unusual dry spells, etc.

Leaders: For the Maryland Experiment Station - T. S. Ronningen and A. O. Kuhn

The experimental nursery has been established in the fall of 1949 in accordance with the plan suggested by the chairman of the regional project. Most of the plots contain satisfactory stands. A soil survey was made and fertilizer and lime were applied consistent with soil test results and regional recommendations.

LADINO WHITE CLOVER IMPROVEMENT

Leader: T. S. Ronningen

Regional Maintenance Nursery (9B3 Project No. NE-10, Objective 2). Approximately 45 clones representing the 21 clones planted at Aberdeen, Idaho and superior clones from the Pasture Research Laboratory will be established in an isolated maintenance nursery in 1950. It is planned to arrange the nursery so that polycross seed may be obtained.

Leaders: For the Cornell Agricultural Experiment Station -
R. P. Murphy, S. S. Atwood, and H. A. MacDonald

This project was activated on July 1, 1949, but the results so far are limited. The plot planting for sub-region 4 (central andwestern New York) was not made in 1949 because of the dry weather, but plans are being made for a spring planting in 1950. Preliminary increase of vegetative material and polycross seed of the outstanding bromegrass clones has been made for regional distribution.

Leaders: For the Pennsylvania Agricultural Experiment Station -
H. L. Carnahan and H. R. Fortmann

The NE-10 Uniform Regional Strain Test was seeded at State College August 30, 1949. Stands were satisfactory but the seedlings were small going into the winter. To date (January 18, 1950) the winter has been open with practically no snow cover and alternating warm and cold weather. Next spring's notes on winter survival should be of considerable interest.

STRAIN TESTING IN PENNSYLVANIA

Leaders: H. R. Fortmann and H. L. Carnahan

A strain testing program including 14 species was initiated in the spring of 1949. Comparable tests with most of the species were established at five locations (representative sites from the four corners and center of the state). The tests are located near Wernersville, Blairsville, Meadville, Harvey's Lake and State College.

A split plot design, with species as the main plots and four replications, was used at all locations. All species were planted alone, in a broadcast seeding in 5' x 20' plots. The numbers of varieties of each species in the tests are summarized below:

Species	No. of Varieties or strains	Remarks
Birdsfoot trefoil	10	
Bromegrass	11	
Meadow Fescue	7	
Meadow Foxtail	1	
Orchardgrass	9	
Lespedeza	11	(Wernersville only)
Perennial ryegrass	4	
Red Clover	8	
Crimson Clover	1	(9 at State College)
Reed Canarygrass	3	
Tall Oatgrass	3	
Alfalfa	5 to 52	(See alfalfa breeding)
Sudangrass	7	(not at Harvey's Lake)
Millets	6	(" " " ")

Excellent stands were obtained for all species except meadow foxtail and timothy.

Table I. Performance of Sudangrass varieties and millets in 1949. Averages based on 4 locations and 4 replications at each location. Split plot design with sudangrass and millets as main plots, broadcast seeding, 5' x 20' plots. Seeded approximately June 1, harvested approximately August 18.

Varieties	Total Dry matter lbs./A	Total Crude Protein lbs/A	Resistance to Foliage Disorders 1=least, 10=most
Sudangrass			
Texas Sweet #372	5438	504	6.67
Sudan 23 (Calif.)	5799	515	5.42
Tift	5425	465	8.75
Wheeler	5878	516	5.33
Colorado	6044	493	5.17
Commercial (Sweet)	6037	513	7.00
Wisc. #797	6098	526	7.58
Average	5817	504	6.56
Browntop	3308	442	7.00
Hungarian	4431	487	5.58
Tennessee German	5861	558	7.58
Proso	3472	448	6.50
Golden	5679	515	6.83
Pearl	8635	618	8.75
Average	5231	511	7.04

A detailed report of these trials will be given in a Pennsylvania State College Progress Report early in 1950. It might be noted, however, that the varieties x locations interaction was highly significant for dry matter production with both Sudangrass and the millets.

Leader: For the West Virginia Agricultural Experiment Station - Collins Veatch

This is one part of the cooperative project of the Northeastern Regional Forage Crops Committee. Seedings of various strains and varieties of alfalfa, red clover, Ladino clover, birdsfoot trefoil, orchard grass, bromegrass, and timothy were made in the fall of 1949.

BROMUS INERMIS BREEDING

Leaders: For the Pennsylvania Agricultural Experimental Station - H. R. Fortmann and H. L. Carnahan
For the Pasture Research Laboratory - A. A. Hanson and K. W. Kreitlow

1. Clonal evaluation:
   a. Polycross hay trial was established with seed from selected clones in a polycross from the Laboratory. Six replications were seeded broadcast in plots 5' x 20', with 40 viable

seeds per square foot in a 7 x 7 triple lattice. This included 42 polycross entries and 5 check varieties.

b. Spaced plants of polycross progeny and maternal clones as in 1-b. under Dactylis glomerata except 7 x 7 simple lattice design was used.

2. Other clonal material to be established in polycross nursery in 1950 with clones in (1) above.

a. 12 Beltsville selections

b. 6 Minnesota selections.

DACTYLIS GLOMERATA BREEDING

Title: Selection, Inbreeding, and Crossing to Obtain Orchard Grass Strains Adapted Particularly for Pastures.

Leaders: For the Maryland Agricultural Experiment Station - T. S. Ronnigen
For the Pennsylvania Agricultural Experiment Station - H. L. Carnahan and H. R. Fortmann
For the Division of Forage Crops and Diseases - R. A. Wagner
For the Pasture Research Laboratory - A. A. Hanson

At College Park, Maryland

Polycross Nursery: A polycross nursery was established in the spring of 1949. It consists of 218 selected clones (instead of the 209 clones originally reported, 1948 Annual Report, page 3) replicated 10 times. The clones were obtained from the polycross nurseries at the Pasture Research Laboratory and at Beltsville. Observational notes were taken in the fall of 1949, and more extensive data will be obtained in 1950.

Progeny Tests of Clones: Polycross progenies of 90 clones were established in the field in 1949 and initial observations were noted. Some of the clones represented are in the polycross nursery described above. The remainder represent seed taken from clones in another polycross nursery at the Pasture Research Laboratory.

At State College, Pennsylvania (Experiment Station)

1. Clonal Evaluation:

a. Polycross yield trial:
From seed from selected plants in a polycross planting of the Laboratory, a seeding was made at the Rockview Prison Farm near State College in the spring in 1949.

All plots will be fertilized with nitrogen since no legumes were used. The planting rate was adjusted to 60 viable seeds per square foot. All seedings broadcast on 5' x 20' plots. Six replications were used. Good stands were obtained.

The material was divided into four maturity groups, the maturity groups being randomized in each replication. A 6 x 6 triple lattice design was used for each maturity group. The nature of the 36 entries in each maturity group is indicated in the following summary:

Type of material tested	Maturity Group I	II	III	IV
Checks Commercial, Hercules Synthetic No. 5	3	3	3	3
Pennsylvania Polycrosses	27	27	27	25
Synthetic Varieties	0	0	0	No. I No. II
N.Y. * Polycrosses	6	6	6	6
Total	36	36	36	36

* Same clones included under Pennsylvania polycrosses.

b. Spaced plants of polycross progeny of the same clones as those mentioned in 1-a to be used as source nursery and also in evaluation of clones provided by the Laboratory.

Four replications were established with 10 plants of the polycross progeny and two plants of the maternal clone per plot. The design was a 6 x 6 simple lattice for each maturity group with the same material as under 1-a included except that seed of restricted polycrosses of clones making up laboratory synthetics was substituted for New York produced polycross seed.

2. Selections from Laboratory plantings for clonal evaluation in 1950.
   a. 29 F_2 plants from "recombination of characters" study.
   b. 8 F_2 plants from (4x) Dactylis aschersoniana x orchard grass.
   c. 16 plants from Ottawa source material.

3. Clones from Cornell to be included in a new polycross nursery with clones mentioned in A and B above.
   a. 10 from S-143
   b. 10 from Brage

4. Evaluation of orchard grass introductions
   a. Seedlings from 34 orchard grass introductions have been started in the greenhouse and will be observed in 1950. The seed was supplied by Dr. L. P. McCann.

At Beltsville, Maryland

Polycross Nurseries: The two polycross nurseries established in the spring of 1947 were maintained through 1949 to observe the selections made in 1948 and to make any further selections that appeared promising. In general, those selected in 1948 were again outstanding in 1949, but there were some exceptions. Thirteen additional selections were made from the Pasture Laboratory material and twelve from the Beltsville clones. Total selections now amount to 72, 47 of which are from the nursery of Pasture Laboratory material and 25 from the Beltsville nursery. Seed was harvested from all plants in 1949 and will be available for progeny testing.

Clonal material of these 72 selections, plus six additional selections from a miscellaneous nursery, was transferred to a new nursery in the fall of 1949. Three replications of five plants of these clones were established. This material will be observed further and selected pending results of the progeny tests. At the appropriate time certain of these clones will be put together as synthetic strains. The old polycross nurseries are to be plowed in the spring of 1950.

In August of 1949 material from these 78 clones was sent to Dr. T. J. Smith, Agricultural Experiment Station, Blacksburg, Virginia, for use in their breeding program.

Progeny Tests: A progeny test of the plants selected in 1948 from the polycross nurseries was seeded in the spring of 1949. Plots of other strains were also seeded to study their performance, as well as to compare them with the polycross seedings. These include the Beltsville strain, an introduction that has been increased in Arizona, a Kentucky strain, a late maturing strain from Massachusetts, Wisconsin 51, Pasture Laboratory Synthetics Plot 1, 3 and 5, two seed sources of Brage, S-37, S-143, and a commercial source.

These plots were seeded in a split plot design of four replications with maturity groups as the main plots. All were seeded in mixture with Ladino clover. In addition, the early maturing group was seeded alone to compare the performance of the material seeded alone and in combination with a legume. Commercial nitrogen will be applied to the pure seedings.

Further Selection and Increase of the Beltsville Strain: Approximately 55 pounds of seed was harvested in 1949 from the increase block of the Beltsville strain. Prior to harvesting the seed the nursery was rogued of inferior plants. The selected plants were removed after harvest and established in another area, that will serve as the new seed increase block of this strain.

Strain Trials at the Agricultural Research Center: In the fall of 1948 plots of commercial, Brage, Beltsville, and Wisconsin 51 were seeded in a pasture at the Dairy to determine their comparative

performance under pasture conditions. These strains were seeded in mixture with red and Ladino clover in plots of 10' x 50', replicated three times. The remainder of the two-acre pasture was seeded to commercial orchard grass, red and Ladino clover. There appeared to be no consistent outstanding differences in the strains in the first year.

Tests of the Beltsville Strain: Seed of the Beltsville strain was sent to seven states in the spring of 1949 for testing. These states include Georgia, Missouri, North Carolina, Pennsylvania, Tennessee, Virginia, and Washington. In addition, seed of the 1949 crop was supplied for the Northeast Regional Testing Program.

T. J. Smith reported that in a test of twenty strains in Virginia, the Beltsville strain was tops in forage production during 1949. The average seed production for 1947 and 1948 in another test, reported by Smith, was 609 pounds per acre. Some of their local strains exceeded this amount, but the introduced materials were somewhat lower.

At State College, Pennsylvania (Pasture Research Laboratory)

Plant Selection: Seed was harvested in the summer of 1949 from each clone within the 7 isolation plots. Four of these plots had been replanted in the fall of 1948 (1948 Annual Report, page 5). Notes were taken in the two polycross nurseries established in the fall of 1947. These nurseries consist of 112 and 85 clones, respectively. Seed collected from selected clones in 1948 was used in establishing the polycross test listed under 1(a). Notes on vigor, maturity, aftermath and leaf disorders, were also obtained in the Ottawa collection, in the F_2 and backcross progenies of tetraploid Dactylis aschersoniana x orchard grass, as well as in some of the superior progenies included within the 97 F_2 progenies planted to study heritable characters in Dactylis glomerata (1948 Annual Report, pages 28 and 29).

PHALARIS ARUNDINACEA BREEDING

Leaders: For the Pennsylvania Agricultural Experiment Station - H. R. Fortmann and H. L. Carnahan
For the Pasture Research Laboratory - K. W. Kreitlow

1. Clonal evaluation:
Notes were taken on the clones in the polycross nursery established in 1948 from seed of clones in a Laboratory planting. There were three maturity groups in this nursery, consisting of 20, 40, and 64 clones in the early medium and late groups, respectively. Highly significant differences between clones were observed for vigor, leafiness, "leaf disorders", aftermath vigor, and general desirability. Polycross seed was harvested from all clones.

Clones have been selected in each of the maturity groups for further evaluation on the basis of progeny performance (10 early, 18 medium, and 19 late).

2. Other clonal material to be evaluated:
   a. 49 clones selected at Cornell.

PHLEUM PRATENSE BREEDING

Title: The Improvement of Timothy by Selection and Breeding

Leaders: For the New Hampshire Agricultural Experiment Station - F. S. Prince, L. J. Higgins and P. T. Blood

Further selections in the parent material of two strains of timothy were made during the year.

Leaders: For the Pennsylvania Agricultural Experiment Station - H. L. Carnahan and H. R. Fortmann

1. Clones to be evaluated:
   a. 56 clones selected at Cornell
2. Source material (to be established in 1950).
   a. Polycross progeny of the 56 clones under 1-a and open-pollinated progeny of existing varieties.

POA PRATENSIS BREEDING

Title: Breeding and Improvement of Pasture Grasses and Legumes

Leader: For the West Virginia Agricultural Experiment Station - Collins Veatch
For the Pasture Research Laboratory - A. A. Hanson

At Morgantown, West Virginia

Seed Production of Selected Strains. All of the seed harvested in 1948 from strains of Kentucky bluegrass resistant to stripe smut Ustilago striiformis was planted and further harvests made.

At State College, Pennsylvania

Additional seed of strain 143 (223) was harvested during the summer of 1949.

LOTUS CORNICULATUS BREEDING

Leaders: For the Pennsylvania Agricultural Experiment Station - H. R. Fortmann and H. L. Carnahan
For the Pasture Research Laboratory - K. W. Kreitlow

1. Source material
   a. 4920 plants from 13 European and American sources were established in the spring of 1948. This material has been evaluated for early spring vigor, date of flowering, uniformity of flowering, resistance to Rhizoctonia spp., aftermath vigor, and growth habit.

2. Polycross Nurseries:
   a. 35 selections from Empire were cloned and established in a polycross nursery in the fall of 1949.
   b. 79 selections from other seed sources have been cloned and will be established in a polycross nursery in the spring of 1950.

MEDICAGO SATIVA BREEDING

Title: Breeding Improved Alfalfa for the Eastern United States

Leaders: For the New Jersey Agricultural Experiment Station - Warren R. Battle and G. H. Ahlgren
For the Cornell University Agricultural Experiment Station- R. P. Murphy, S. S. Atwood, H. A. MacDonald, E. D. Donnelly, G. G. Gyrisco and L. J. Tyler
For the Pennsylvania Agricultural Experiment Station - H. R. Albrecht, H. R. Fortmann, and H. L. Carnahan
For the Rhode Island Agricultural Experiment Station - H. M. Tysdal
For the Division of Forage Crops and Diseases - O. S. Aamodt
For the Pasture Research Laboratory - A. A. Hanson and K. W. Kreitlow

The Eastern Alfalfa Improvement Group includes representatives from Ohio, Virginia, and North Carolina in addition to states in the Northeastern Region. A meeting was held at New Brunswick, New Jersey August 8 and 9, 1949. The present status of clones and polycross progenies in the cooperative tests and the new clones to be included were discussed. A description of the origin of each of the following varieties was presented: Ranger, Buffalo, Atlantic, Williamsburg and Narragansett. A detailed report of the meeting was mimeographed and distributed by the secretary of the group, S. S. Atwood of Cornell University.

At a later meeting, January 5 and 6, at Beltsville, Maryland, representatives of the Eastern Alfalfa Improvement Group reviewed the performance of clones that had been assigned "C" numbers. Of the 185 "C" clones that have been tested, 60 were selected as worthy of additional progeny testing throughout the region. Fifty new clones appeared to be promising enough to include in these tests.

At New Brunswick, New Jersey

Wilt susceptible plants have been isolated and eliminated from the Atlantic selection nursery during the past season. Artificial inoculation has been used and this work will continue for an additional time. A goodly number of the best lines used in the composition of Atlantic are included in the test and it is hoped that superior plants resistant to wilt can be found for future recombination.

A study in which various generations of Atlantic seed are being compared has also been established. This test includes breeders' seed, foundation, registered and certified seed. There is some question as to whether there is a loss in vigor and other characters with advancing generations. It is our hope that the problem can be answered at least in part by these comparative plantings.

Further data were secured from the advanced alfalfa nursery but a severe infestation of Sclerotinia has nullified much of the value of this work. There appeared to be no plants in the nursery resistant to this disease and we should probably eliminate this experiment.

Work is also being conducted on the isolation of superior alfalfa clones. A number of these that appear to be promising are being suggested for inclusion in the National alfalfa clone test program.

Another study has to do with a relationship of seedling vigor and general yields of alfalfa. Preliminary work indicates that it may be possible to isolate high yielding strains through early seedling measurements, thus reducing the expense and the time involved in finding varieties capable of high productiveness.

At Ithaca, Churchville, Tully, and Four Regional Test Plots, New York

All of the data for the 1949 growing season from this project have been summarized previously in tabular form in the 1949 Annual Report of the Uniform Alfalfa Nurseries. Only brief summaries of these results will be included here.

1945 Clonal Nursery. The best clones (38 in number) were established in the replicated 1949 clonal nursery in the spring at the Underwood plots and notes on establishment, vigor and disease reaction were recorded in the fall. These data will be reported next year. The 1945 clonal nursery was discarded in the fall of 1948 and no further data will be reported.

1946 Clonal Nursery. The best clones (21 in number) were removed and established in the replicated 1949 clonal nursery at the Underwood plots. This nursery was discarded in the spring of 1949 and no further data will be reported.

1947 Clonal Nursery. The growth of plants in this nursery has been rather unsatisfactory. The planting was plowed in the fall of 1949 and no further data will be reported. The best clones were removed and will be established in a replicated clonal nursery in 1950. Several clones which showed a low incidence of Pseudopeziza leaf spot from natural infection were selected from the material supplied by Dr. F. R. Jones.

1948 Clonal Nurseries I and II. Extensive notes on a large number of characters were taken during the 1949 growing season. This season was dry and hot and a very good seed set was obtained for this environment. Consequently seed for a polycross progeny test to be planted in 1950 was harvested from 143 selected clones. This includes 65 C-clones and 78 new clones from New York origin. A number of these new clones appear to be promising as measured by clonal performance although the determination of their reaction to bacterial wilt is incomplete.

1949 Clonal Nursery. This replicated nursery was established in the spring of 1949 on the Underwood plots and includes the best clones (148 in number) selected from the 1945, 1946, and 1947 clonal nurseries and from seedling nurseries planted in 1945 and 1946. Notes taken in the fall on the establishment, vigor and disease reaction of these clones will be reported in the 1950 report.

Selections for Selfing and Diallel Crossing in 1948-49. Ninety clones which were selected primarily from the 1946 and 1948 clonal nurseries because of their outstanding superiority in one or more characteristics and their satisfactory performance in all others were selfed in the greenhouse in the winter of 1948-49. Sufficient seed from 82 of these clones was obtained so that replicated 10-plant spaced seedling rows were established in the summer of 1949. In addition, all possible single crosses were made in the greenhouse during this same winter among the parental clones within each of six groups of clones selected for specific reasons. These six groups are as follows:

Group	No. of clones	Clones	Desirable characteristic
1	5	C-14, -27, -51, -53, W-10	Persistence
2	5	C-49, -57, -134, -199, W-10	Leaf spot resistance
3	7	C-40, -53, -57, -72, -196, -199,	Leafhopper "
4	5	C-10, -12, -40, -59, W-28 /W-28	Blackstem "
5	10	C-10, -27, -40, -46, -53, -57, -59, -72, -196, -199	Vigor
6	5	C-27, -53, -57, -196, -199	Best

Seed of all crosses was obtained. Six replications of 75 single crosses and of eight check varieties and three replications of 17 parental clones in 10 spaced-plant rows were established on each of two soil types during the spring. Excellent establishment was obtained and some notes were taken in the fall and these will be reported in 1950.

Pseudopeziza Leaf spot and Wilt Inheritance. This is a thesis study by Mr. Donnelly. Several of the best clones as determined by their performance at Ithaca have been crossed with the most wilt-resistant clones isolated from the breeding program at Davis, California and the F_1 and backcross progenies are being studied. The variety, Ontario Variegated, is being "screened" for wilt resistant plants and the progeny from the wilt-free plants selected from the first screening will be tested in the winter of 1949-50. The studies with leaf spot have not progressed so far and another graduate student, Mr. R. D. Ensign is making crosses between clones resistant and susceptible to leaf spot during the winter of 1949-50; these progenies will be studied in 1950.

Observational Nurseries. These nurseries have been established in four replications of 9-foot seeded rows each year beginning with 1945. This first nursery has been discarded. The nurseries planted in 1946, 1947, 1948 and 1949 were all established with good stands and two cuttings per year have been obtained after the seeding year on all of them. The results have been presented each year in the annual reports of the uniform alfalfa nurseries. These data plus those obtained from the clonal nurseries have been useful in the selection of the most promising clones for the regional breeding project established under RMA Project N.E. 10.

Plot Yield Trials

1. Churchville - seeded April, 1946.
   This experiment includes all of the important varieties as well as a few of the polycross and single cross entries from the 1945 and 1946 Uniform Advanced Nurseries. Although the growing season of 1949 was very dry, two cuttings of hay were obtained. The stands on many varieties continued to decline. Wilt symptoms have been prevalent, especially in the fall of both 1948 and 1949. It is thought that very little winter injury has occurred during these two years and that some factors other than wilt susceptibility have been in part responsible for this reduction in stand. It is significant that Ranger and several progenies of selected clones have maintained their initial stands of 75 to 80 per cent whereas Grimm and others have been reduced to 5 to 30 per cent. The stands for Buffalo and Atlantic have been reduced to 60 and 50 per cent respectively. Ranger was the highest yielding variety in 1949 and Ranger and Atlantic have been the highest yielding for the three-year period.

2. Tully - seeded June, 1947. Thirty-five varieties were planted in four replications alone and in four with bromegrass. Two cuttings were taken in 1949 although this area was also very dry. The stands have become very variable and the cause is unknown. Narragansett has been the highest yielding variety in both 1948 and 1949, both alone and with bromegrass. Its seedling vigor, establishment, appearance and per cent stand in the fall of 1949 have been good to outstanding.

3. Pulleyn field, Ithaca - seeded May, 1947. This planting is a duplication of the one made at Tully. No yields were taken in 1948 because of a variable growth and a high infestation of weeds. Fair stands and a rather good growth was noted in the fall of 1948 and the spring of 1949 so that two cuttings were taken in 1949 even though it was a dry year. Again, Narragansett was the highest yielding variety and it's superiority had also been evident from visual observations made in 1948.

4. Katola field, Ithaca - seeded June, 1947. Two cuttings were taken from the four varieties; Atlantic, Ranger, Buffalo and Ontario Variegated planted on these plots which are on a poorly drained, non-alfalfa soil type. Atlantic and Ontario Variegated were higher in yield and had better stands than Buffalo and Ranger. These plots were discontinued after the 1949 growing season.

5. Regional plots. These regional plots have been established on farmers' fields in cooperation with Professor A. A. Johnson as demonstrational yield trials. One was established in Columbia County in 1947 and had Atlantic, Buffalo, Ranger and Ontario Variegated seeded in four replications, both alone and in mixture with bromegrass. This trial was harvested twice in 1948 and again in 1949 and all varieties have been equal in performance. In the spring of 1948 these four varieties, plus Narragansett, were established in similar trials in each of three counties; Montgomery, Onondaga and St. Lawrence County. Good initial stands of all varieties were noted in the fall of 1948. In the growing season of 1949, two harvests were made in all but the St. Lawrence County trial where the drouth was so severe that the second cutting was not made. In these trials on good alfalfa growing soils Narragansett was outstanding in yield and per cent stands in 1949, the first harvest year.

6. Uniform Advanced Nursery A Plots - Lambkin field - Ithaca. This trial was seeded in four replications alone in 1948. No yields were taken in 1949 because of great variability in rate of growth and degree of weed infestation. The stands were much more uniform in the fall of 1949 and it is planned to harvest these in 1950. The DuPuits introduction and Narragansett appeared outstanding in vigor and stand along with several seed progenies of selected clones.

7. Uniform Advanced Nursery B Plots - McGowan field - Ithaca. This trial was seeded in four replications alone in 1948 and included all of the important varieties and a few of the seed progenies of selected clones. Two harvests were made in 1949. Atlantic, Ranger, Narragansett, Ontario Variegated and the new synthetic varieties were equal in performance.

The evaluation of the seed increases of Ranger - Lambkin field - Ithaca. This study was designed to test the performance of the various seed increases of Ranger from Syn-1 through Syn-3 made in the several states where seed of this variety has been increased. Plantings in plots and in spaced 10-plant rows in six replications were made in 1948 and were studied intensively in 1949. This trial has been a part of a thesis study for Mr. S. P. Kohli. To date no significant differences among the various increases of Ranger have been found that are of a practical significance.

The evaluation of the new synthetic varieties and their parents - Lambkin field - Ithaca. A replicated row and spaced 10-plant row trial of the three synthetics; A-224, A-225, and A-226, and their parents was planted in 1948 and studied in 1949. Clonal, wide polycross and narrow polycross (seed harvested from each clone separately in the Syn-1 production field) progeny for each parental clone were studied. Considerable valuable information was obtained from this type of test. As an example, the poor performance of C-22 in A-226 was well brought out by this type of test. If all of the parental clones and their seed progenies had been studied in detail before at this location, this type of test might not have seemed necessary.

Greenhouse Tests for Insect Resistance. In the winter of 1947-48 preliminary results on the reaction of a number of the selected clones to pea aphid attacks were obtained. During the winter of 1948-49 further preliminary data on pea aphid attacks were obtained and attempts were made to devise a satisfactory method of testing the reaction of clones to leafhopper attacks. In the winter of 1949-50 studies with the leafhoppers are being continued. In future years, it is planned to continue this work with a selected group of the best clones.

At State College, Pennsylvania (Experiment Station)

1. Advanced Uniform Nurseries
   a. (1) State College, 36 entries (1948)
      (2) State College, 30 entries (1949)
   b. Wernersville, 25 entries (1949)
   c. Blairsville, 25 entries (1949)
   d. Nazareth, 20 entries (1948)
2. Observation Nurseries
   a. (1) State College, 81 entries (broadcast)(1948)
      (2) State College, 52 entries (rows) (1949)

The data from the above tests have been analyzed and the report will be included in the annual report of the Alfalfa Improvement Conference.

At Kingston, Rhode Island

Data from two advanced test and two polycross nurseries were obtained in 1949. An additional polycross nursery was planted and also another advanced nursery. The season was the driest on record, with very little rainfall from the last of May until early September.

A very fine first cutting of alfalfa was obtained on both advanced nurseries. A small second cutting was also harvested from one of these nurseries but not on the other due to the lack of growth.

The leading varieties and selections in the nursery planted in 1945 were Nebraska 49-1282, Ranger (Syn 1), Hardistan, 39-1220 and Buffalo. In the nursery planted in 1946 the highest yields for the single crop harvested were obtained from 57-C45, Narragansett and 56-C8XC21.

The season was very favorable for seed production. About 50 pounds of Narragansett alfalfa seed were produced on less than 1/4 acre. Arrangements have been made for increasing seed of this variety in several seed-producing areas so that it can be given wider adaptation tests.

At Beltsville, Maryland

Activities consisted of gathering observational data on the agronomic characters and performance, and disease reaction of four clonal nurseries established in 1946, 1947, 1948, and 1949. No yields were taken since each line under test consists of only twelve individual plant rows, not all of which are planted in duplicate plots. Striking results have been obtained on leaf blotch, yellowing, crown rot, vigor, and stand survival. The progressive action of these factors during the four year period has been very striking.

This past year observations on crown rots in the three oldest nurseries have demonstrated remarkable differences between the reaction of clonal lines to the complex of organisms causing this disease. The most interesting observations were made in the late fall, following the first early frosts of the season. The primary organism associated with the disease was Colletotrichum. Our results during the past year would seem to indicate that greater attention needs to be given to the nursery material in the late fall. Much of the damage observed might otherwise readily be classified as winter injury or winter killing in the following spring.

Seeded plots of uniform nurseries were established during the past year. Excellent stands were obtained and more specific data should become available in another year on some of the newer synthetics that are being produced by the plant breeders in the different parts of the country.

At State College, Pennsylvania (Pasture Research Laboratory)

Plant Selection: Two replications of the 225 clones established in 1948 were clipped once at the normal hay stage in 1949, while the remaining two replications were clipped three times (1948 Annual Report, page 12). Notes were taken in all replications on recovery, leafhoppers, wilt, and black stem and additional observations made on hay, vigor, and leafiness within the two replications cut for hay. Several new selections responded very favorably to the differential clipping treatment but the selection of material for further testing will not be made until 1950.

Though the number of superior plants within the F_2 progenies planted in 1948 appears to be limited, (1948 Annual Report, page 12) nevertheless a few plants will be preserved for additional tests.

TRIFOLIUM PRATENSE BREEDING

Title: The Improvement of Red Clover by Selection and Breeding

Leaders: For the New Hampshire Agricultural Experiment Station - L. J. Higgins, F. S. Prince and P. T. Blood
For the Pennsylvania Agricultural Experiment Station - H. L. Carnahan and H. R. Fortmann and R. G. Hanson
For the Pasture Research Laboratory - K. W. Kreitlow

At Durham, New Hampshire

Intercrossing among families with a perennial tendency was continued during the year. Progenies from these crosses are being propagated.

Testing of the New Hampshire strain along with seven other varieties was conducted during the year. Listed in descending order of yield of the first cutting the various strains ranked as follows: Dollard, New Hampshire, Cumberland, Ottawa, Purple seeded, Kenland, Wisconsin Mildew resistant and Midland. Severe rodent damage to second crop, coupled with drought, interfered with satisfactory yields. Seedings for this test were made in 1948.

At State College, Pennsylvania (Experiment Station)

1. Source material.
   a. A source nursery consisting of open-pollinated progeny of plants selected from the following varieties:

Strain	No. of Parent Plants selected
Scott	42
Kenland	39
Bashore	33
Midland	36
Cumberland	33
Wisconsin Mildew resistant	43

Thirty-six progenieswere grown from each parent plant selected. The plants were grown in a spaced planting (40" x 40") in twelve-plant plots with three replications.

This material has been evaluated for vigor and mildew-resistance.

At State College, Pennsylvania (Pasture Research Laboratory)

Resistance to Fusarium. (Preliminary work on this project was started in 1947 in cooperation with M. T. Henderson (See Pa. Bull. 502, page 16, 1948 and Pa. Bull. 515, page 11, 1949). As a result of preliminary observations and tests, it was obvious that extensive experimental work would have to be done before potentially resistant material could be evaluated.)

Observations and reports indicate that in recent years, it has become increasingly difficult to maintain stands of red clover (Trifolium pratense) in Pennsylvania as in other states. Examination of red clover stands showed that many were seriously depleted during midsummer of their second year. External symptoms first developed in the leaves which curled at the edges, turned grayish and then wilted. Death of affected plants occurred during periods of hot, dry weather. The interior of the crown and tap root of dead and dying plants was almost invariably discolored brown to almost black depending upon severity of infection. From such diseased plants pure cultures of Fusarium spp. were readily isolated. When plants of red clover were inoculated artificially with cultures of Fusarium previously isolated from diseased red clover plants, they in turn developed typical internal discoloration of the tap root characteristic of the disease. Cutting or scarifying the tap root aided rapid infection. Uninjured plants were more difficult to infect. Field observations had led to the suggestion that wounds of the clover root borer provided one of the avenues for entrance of the pathogen.

During 1947, 52 isolates were obtained from diseased red clover plants collected in different parts of Pennsylvania. Two types of Fusarium cultures were consistently obtained as well as a third unidentified organism. The highly pigmenting isolates predominated and were identified as Fusarium oxysporum and F. solani. Preliminary pathogenicity tests conducted with representative cultural types were inconclusive apparently because of fluctuating environmental conditions during the test.

In the fall of 1949, an extensive survey trip was made through some of the northeastern states to collect diseased red clover and determine, if possible, whether the same Fusarium species were responsible for red clover failure in other parts of the region as in Pennsylvania. In addition to collections from Pennsylvania diseased plants were either collected in or received from the following states: New York, Vermont, New Hampshire, Massachusetts, Connecticut, New Jersey, Ohio, Maryland, and Rhode Island. More than 100 isolates were obtained and are at present being classified with respect to morphology and rate

of growth on different culture media and at different temperatures. Additional tests will include pathogenicity to red clover and other species of plants. Preliminary data indicate that most cultures resemble Fusarium oxysporum although several other species were also isolated.

In order to obtain consistent results when testing for resistance to the disease, experiments were designed to provide answers to several questions concerning environmental conditions most conducive to development of the disease.

One of the first problems was to devise a technic for introducing the organism into the plant. Since observation showed that infection occurred principally through the crown or tap root under field conditions, efforts were made to introduce the organism by means of infested soil. After testing several methods, best results were obtained by growing the Fusarium cultures on a grain mixture, drying the mixture at room temperature and grinding to a uniform size. This dried grain inoculum was similar to that previously developed for use in inoculations with Sclerotinia trifoliorum. For most tests, a mixture of 12 pathogenic isolates was used. Best results were obtained by opening a trench in the soil, spreading a thin, uniform layer of dried, grain inoculum in the bottom of the trench and then placing the pruned and scarified roots of the test plants in direct contact with the inoculum. The inoculum was moistened and earth was again pushed around the roots and the plants incubated 10 days to 2 weeks.

Field observations suggested high temperatures might contribute to rapid killing of infected plants. This was demonstrated by the growth of red clover plants inoculated with Fusarium at several controlled temperatures. As shown in Table 1, severity of infection increased as temperature was increased. The optimum temperature for growth of Fusarium isolates on potato-dextrose agar was 30°C which approximated the optimum temperature for infection.

Earlier tests indicated age of plants inoculated with Fusarium might influence severity of infection. As shown in Table 2, inoculated plants younger than 6 weeks old were not infected as readily as older plants. In addition, it was discovered that plants older than 6-8 weeks contained an increasing number of plants that were naturally infected, probably during transplanting. It was, therefore, concluded that plants 6-8 weeks old were most desirable for large-scale tests.

Preliminary tests during 1949 suggested that there may be resistance to Fusarium among strains of red clover. Large-scale tests are underway in which replicated rows of strains are being tested for resistance in Fusarium-infested soil in a greenhouse bench. The soil temperature is maintained by thermostatically controlled heating coils imbedded in the soil. Excellent results have been obtained with this equipment to date.

Tests with other species of Trifolium, Medicago, and Melilotus showed most species were susceptible. However, Trifolium repens (white Dutch and Ladino), T. fragiferum and Melilotus suaveolens resisted infection.

TABLE I

SUMMARY OF THREE TESTS WITH RED CLOVER PLANTS INOCULATED WITH FUSARIUM AND INCUBATED UNDER CONTROLLED TEMPERATURES.

Temp.		Dead	Sev.	Mod.	Sl.	0
65°F.	Inoc.	8	46	35	33	10
	Ck.	0	0	6	9	4
75°F.	Inoc.	26	68	17	10	4
	Ck.	0	0	6	10	8
85°F.	Inoc.	102	22	1	0	0
	Ck.	9	6	0	2	3
95°F.	Inoc.	112	16	4	3	0
	Ck.	7	2	0	2	4

TABLE II

EFFECT OF FUSARIUM ON KENLAND RED CLOVER SEEDLINGS OF DIFFERENT AGES

	Degree of Infection	Age in weeks 3	5	6	8	10	12	13	16
Control	Dead	0	0	0	0	0	0	0	3
	System	0	0	1	2	2	3	6	6
	Healthy	10	10	9	8	8	7	4	1
Inoc.	Dead	23	26	37	31	29	29	32	31
	System	8	8	2	9	9	10	7	8
	Healthy	9	6	1	0	2	1	1	1

Resistance to Sclerotinia trifoliorum. To date, 95 strains of red clover have been tested as seedlings and 114 strains as older plants. Infection was accomplished by placing dried grain inoculum of S. trifoliorum similar to that used for Ladino clover inoculations around the crown of plants to be tested. The inoculated plants were then incubated at 15°C in a greenhouse bench moist chamber or in a cold room. Of 50 plants that survived two inoculations, only a few persisted through three inoculation tests. Nine of the plants that survived two inoculations were polycrossed but the progenies have not yet been tested. In addition, crosses are being made between resistant and susceptible plants and their progeny will be tested later.

In a recent clonal test several plants with promising resistance survived heavy inoculation. One of the plants from the strain Frandsen 413 had 6 survivors from 6 plants tested; fairly high clonal survival also resulted from plants selected from the strains Red Russian and Tennessee Purple.

TRIFOLIUM REPENS BREEDING

Leaders: For the New Hampshire Agricultural Experiment Station - F. S. Prince, L. J. Higgins and P. T. Blood
For the New Jersey Agricultural Experiment Station - G. H. Ahlgren
For the Pennsylvania Agricultural Experiment Station - H. R. Albrecht, W. E. Knight
For the Pasture Research Laboratory - A. A. Hanson

At Durham, New Hampshire

Intercrossing among promising families was continued during the winter of 1948-49. Seed produced from interspecific crosses during the winter of 1947-48 was germinated, set in spaced rows in the nursery, and rated during the season. Promising material has again been placed in the greenhouse for intercrossing during the winter.

Much disease developed during the winter of 1948-49 in the field. This disease was diagnosed as Sclerotinia trifoliorum. At least 20 per cent of the area in which 800 plants had been set in July, 1948 was affected. The winter weather was very open with snow cover at infrequent intervals only.

At New Brunswick, New Jersey

Progeny Tests of Diallel Crossing System.

Seed Production. Seed production of the three crosses, namely 6-5 x 6-16, 6-10 x 6-13, and 6-9 x 6-12 was continued in 1949. A goodly quantity of seed of the cross 6-10 x 6-13 is available, but only small amounts of the other two hybrids have been secured. Seed production has also been continued on the close pollinated clover plots and there is a small amount of this seed available.

Field Plot Tests. The small plots established in the fall of 1947 with 2 replications in which 5 strains were compared have been continued in 1949. The data are relatively similar to those reported for 1948.

In addition, the New Jersey hybrid 6-10 x 6-13 has been planted in plots replicated 3 times and randomized for comparison with 18 strains collected from various parts of the United States as well as Italy. These plots were established in the spring of 1949 and only observational data have been secured on them so far.

At State College, Pennsylvania (Pasture Research Laboratory)

Progeny tests of Ladino clover clones. Notes were obtained from the polycross progeny test of the 103 clones included in the 1947 polycross nursery (1948 Annual Report, page 14). The winter of 1948-49 was very mild and differential survival between progenies was negligible. The progenies did respond differentially, however, to the midsummer drought in 1949. Final selections are planned for the spring of 1950.

Selection and evaluation. The polycross planting representing 228 new selections from the 1946 polycross was replanted in the spring of 1949 (1948 Annual Report, page 15). Seed will be harvested from this planting in 1950. A source nursery of 1000 spaced plants was established from polycross seed produced in Idaho.

Six clones rated as good and five clones rated as poor, from the standpoint of persistency, were selected from the 103 clones in the 1947 polycross (1948 Annual Report, page 15). During the winter of 1948-49 the 6 good clones were crossed in all possible combinations, the 5 poor clones were handled in a like manner, and each clone was included in an intercross of good x poor. The F_1 seed was planted in the greenhouse and the seedlings transplanted to a replicated plot experiment with the plants 12 inches apart within plots.

In addition 3 replicated plot trials were established representing progenies from 27 of the 103 clones included in the 1947 polycross. There was not sufficient seed of the 5 poor clones to include them in these trials. The seed supply limited the plantings as follows: at State College (a) 4 replications of all 27 progenies seeded alone, (b) 19 of these progenies seeded with orchard grass in 4 replications; at Harvey's Lake, Luzerne County, 4 replications of 16 progenies seeded alone.

Notes taken in the fall of 1949 indicated considerable variation in growth habit both among the single cross progenies and among the polycross progenies. Detailed notes on persistency and vigor will be taken in 1950.

A space-planted clonal nursery, including the 27 clones mentioned above as well as the 11 parental clones, was planted in the spring of 1950. This nursery will provide comparisons between the original clones and aid in interpreting the response of the single cross and polycross progenies.

Clonal material representing the 6 good and the 5 poor parents as well as their F_1 progenies was brought into the greenhouse in the fall of 1949. The morphological and physiological characteristics of these clones will be studied to determine what characters if any are correlated with field behavior.

NUTRITION STUDIES

Title: The chemical composition of the pasture grasses

Leaders: For the New Hampshire Experiment Station - T. G. Phillips
For the Pasture Research Laboratory - J. T. Sullivan

Studies have been continued on grasses growing in small plots at State College, Pennsylvania. Chemical analyses are being made partly at the New Hampshire Station and partly at the Pasture Research Laboratory (1948 Annual Report, page 16).

Analyses were continued on the grasses harvested in 1948 at different stages of maturity. Constituents not completed in time for last year's report were sugars, fructosan, and acid-hydrolyzable carbohydrates and cellulose by the Kurschner and Hanak method. Sugars showed fluctuations which may be sufficient to account for the drop in "other carbohydrates" observed between May 25 and June 8 (1948 Annual Report, page 16). Sucrose varied between species from a low of 2% in Kentucky bluegrass to a high of 13% in brome, both at dough stage. Fructosan was present in 5 species and increased with maturity, but was absent in alta fescue, brome, and orchard grass, the tops only being sampled. The K and H method for cellulose gave results which paralleled those by the hypochlorite method (1948 Annual Report, page 16), but was about one-third lower since it did not include some associated hemicelluloses or cellulosans.

Statistical analyses were carried out on the data from the standpoint of correlations, significance between species and between stages of growth. In all species except timothy, protein correlated negatively with both cellulose and lignin while the latter two correlated positively with one another.

During 1949 cuttings were made from the same plots, but were increased in number to include more stages of growth, as follows:

I. Vegetative stage. Heads were formed, but not emerged. Lower internode was beginning to elongate. The time varied from April 26 in tall oat grass to May 10 in timothy.
II. Heads half emerged from boot. From May 6 in Kentucky bluegrass to June 14 in red top. These two species continued to be the extremes.
III. Heads fully expanded. May 18 to June 24.
IV. One-fourth of heads in bloom. May 24 to June 27.
V. Seeds at milk stage. May 27 to early July.
VI. Seeds at dough stage, June 3 to July 5.

Analyses are being carried out as with the 1948 samples. Those for protein, cellulose (R & H), lignin, and crude and soluble ash have been completed. Changes in composition from one stage to another were similar to those of 1948. In all species and with few exceptions protein decreased significantly between any two successive sampling dates. Protein differences between species

at the same stage were usually significant, reed canary and bromegrass being most frequently highest in protein and timothy the lowest. Reed canary was also highest in soluble ash and lowest in lignin. Comparisons at the same date often gave different relationships from comparisons at the same stage of growth. The two short grasses, Kentucky blue and red top, were not essentially different in composition from the larger species.

Two clones of orchard grass in spaced plantings differed in protein as did any two species which matured at different times. The early and late clone contained at half emergence of the head (20 days apart) 16.5 and 11.1% protein respectively and at full bloom (also 20 days) 8.4 and 7.1%.

Title: Measurement of the Nutritive Value of Pastures and of Pasture Plants

Leaders: For the Pennsylvania Agricultural Experiment Station - R. W. Swift and J. B. Washko
For the Pasture Research Laboratory - J. T. Sullivan and V. G. Sprague

The nutritive evaluation of five samples of grasses, one each of Kentucky bluegrass, bromegrass, and timothy, and two of orchard grass (first and third cutting), harvested in 1948, has been completed. (1948 Annual Report, page 15). During 1949 another first cutting of orchard grass was made at the time when the heads had emerged in order to compare with those of 1948. A sufficient quantity of second cutting alfalfa to provide for digestion trials with 7 sheep, was harvested July 20 and 21. Their evaluation has also been completed. These forages were treated as nearly identically as possible, all being dried in a special hay drier immediately after being cut.

Each forage was fed to at least 2 groups (usually 4 in a group) of sheep from which complete energy balances were obtained including body gain of fat and protein, and the production of heat, methane, feces and urine. In addition to these calorimetric measurements, apparent digestibility was also determined in numerous additional feeding periods. Considering an eleven-day collection period with one sheep as a unit, the digestibility data for timothy are based on 18 units, bromegrass on 21 units, orchard grass (1st cutting) on 21 units, orchard grass (3rd cutting) on 8 units, orchard grass (1st cutting, year following) on 4 units, Kentucky bluegrass on 13 units, and alfalfa on 7 units.

The forages were evaluated on the basis of digestible dry matter, digestible energy, total digestible nutrients and metabolizable energy. No significant differences were found between sheep nor between plots of a given forage.

The composition of the forages (standard feed analysis) did not vary appreciably between plots. The third cutting of orchard grass contained considerably more protein and ether extract (dry matter basis) than did the first cutting, these values being 20.73% vs. 12.44% and 5.63% vs. 3.51% respectively. It is of interest to note that the digestibility of the constituents other than protein, in the first cutting were definitely higher than in the third cutting. The superior digestibility of the protein in the 3rd cutting (77.3% vs. 67.8%) is more than balanced by the reverse finding with regard to all the other constituents, (ether extract, crude fiber, etc.) so that the nutritive value on the basis of digestible dry matter or T.D.N. indicates a superiority of the first cutting while the more precise metabolizable energy determinations reveal the two forages to be of equal value. The gross energy of the first cutting of orchard grass was 4486 calories per gram dry matter as compared to 4778 calories for the third cutting.

The 1st cutting of orchard grass in 1949 was obtained 9 days earlier in the year than the corresponding sample in 1948 and resulted in digestion coefficients intermediate in value between those of the first and third cuttings of 1948. Data are too numerous to include here except for a very brief summary which may be shown in tabular form as follows.

Table III

Metabolizable Energy, Digestible Energy, Digestible Dry Matter and Total Digestible Nutrients

	Per Kilogram Dry Matter				
	Gross Energy	Metabolizable Energy	Digesti-ble energy	Digestible dry matter	Total digestib nutrient
	Cal.	Cal.	Cal.	Kg.	Kg.
Timothy	4533	2162	2600	.609	.606
Alfalfa (1949)	4614	2290	2817	.619	.596
Bromegrass	4483	2516	3017	.706	.694
Orchard grass 1st cutting (1948)	4486	2513	3123	.728	.710
Orchard grass 3rd cutting (1948)	4778	2523	3157	.697	.686
Orchard grass early 1st cutting (1949)	4646	2574	3166	.711	.710
Kentucky bluegrass	4639	2677	3196	.724	.714

It is of interest to note that in general, the forages fall into the same place regardless of the evaluation method employed. Statistical studies show highly significant differences between either alfalfa or timothy and the other grasses.

Plans for next year include a similar evaluation of Ladino clover, cuttings at frequent intervals, of one forage throughout the year, and hay made throughout a range in cutting from "too early", to "too late".

PASTURE MANAGEMENT EXPERIMENTS.

Title: Evaluation of Grasses and Legumes for Hay, Grass Silage and Pasture for Dairy Cattle (With Pennsylvania).

Leaders: For the Pennsylvania Agricultural Experiment Station - C. B. Knodt, P. S. Williams and A. L. Haskins
For the Pasture Research Laboratory - V. G. Sprague

Systems of Grazing Management on Orchard Grass-Ladino clover. Fields of orchard grass-Ladino clover used for investigating five grazing management systems (Annual Reports for 1945, 46, 47 and 48) were grazed with dairy cattle for the fifth consecutive year. Milk yields under all systems of management were higher in 1949 than in 1948, due in part to the volunteer reestablishment of Ladino clover on these plots during 1948. By the fall of 1949 good stands of clover were present on the early grazed paddocks and also on the grass-silage plus grazing paddocks, but on the deferred grazing paddocks the clover stand was poor. The 5-year average and 1949 production are presented in Table IV.

TABLE IV

Production of Milk and Silage from an orchard grass-Ladino clover Association under Different Grazing Management Treatment Systems.

Grazing Management Treatments	Pounds per acre 4% FCM from grazing		Tons per acre Silage 30% DM	
	1949	5-year av.	1949	5-year av.
Early spring + rotational grazing	5276	7208	-	-
Deferred spring grazing + rotational grazing	6137	7939	-	-
Early spring grazing + silage + rotational grazing	4317	4922	0.8	1.46
Silage + rotational grazing	2979	4040	2.6	3.5
Continuous grazing	5838	7577	-	-

Evaluation of Several Grass-Legume Mixtures for Grass Silage and Aftermath Grazing. Silage from five grass-legume mixtures (Annual Reports for 1945, 46, 47 and 48) was harvested in 1949 and the aftermath was grazed. Milk yields obtained from aftermath grazing of the alfalfa-grass association were as high or higher than at any time during the past 5 years. This may have been caused, in part, by the fact that the 1949 season was long enough to permit three aftermath grazings of the alfalfa whereas in other years only two were available. While alfalfa stands on several paddocks were badly thinned by wilt, on others injury was only slight. Ladino clover had been lost from the orchard grass and bromegrass associations in 1948. Although it was present in two of the three timothy-Ladino clover replications, it was completely missing in the third as was also the timothy. Timothy in the other replications had been thinned out as had the bromegrass in association with Ladino clover. The average production of silage and milk from aftermath grazing for the five years is presented in Table V. Production of silage and also milk from aftermath grazing have been higher from the alfalfa-grass combination than from Ladino clover grass associations. In large part, this was due to the productivity and persistence of the alfalfa under these carefully controlled management treatments. This experiment was terminated at the end of the 1949 season.

TABLE V

Production of milk and silage from various grass-legume associations managed for silage plus aftermath-grazing.

Plant Association	Pounds per acre 4% FCM from grazing		Tons per acre Silage 30% DM	
	1949	5-year av.	1949	5-year av.
Orchard grass-Alfalfa	5701	5516*	7.8	6.5
Orchard grass-Ladino clover	2147	4745	3.3	4.4
Bromegrass-Alfalfa	6161	4935	6.6	7.8
Bromegrass-Ladino clover	1826	4820	3.5	5.1
Timothy-Ladino Clover	2287	4363	4.2	4.7

* 4-year average

Title: Grassland Renovation Trials in Connecticut

Leaders: For Storrs Agricultural Experiment Station - B. A. Brown and R. I. Munsell
For the Pasture Research Laboratory - V. G. Sprague

In the late fall of 1948, the two-acre grazed plot (7W), disked in the fall of 1942 and seeded with Ladino clover at 2 pounds per acre in the early springs of 1943 and 1946, was divided into four unfenced quarters, two of which received cow manure at 10 tons per acre at that time. In the early spring of 1949, one of the manured and one unmanured quarter were reseeded with Ladino clover at 2 pounds per acre. The purpose of these treatments was to test

the occasional beneficial effects of manure in establishing newly seeded Ladino clover or in favoring the spread of old Ladino clover plants on permanent grassland. No differences in the prevalence of Ladino clover were noted during the 1949 season which, incidentally, was the driest for June, July and most of August of any like period in, at least, sixty years. The yield, as measured by grazing with yearling Holstein heifers, ranked third highest among seventeen pastures.

Also, in the fall of 1948, another two-acre grazed plot (4N) was thoroughly disked to kill the grasses, chiefly Kentucky bluegrass. This plot had received liberal LPK fertilization in recent years and more lime and potash were added before seeding Ladino clover at 2 pounds per acre in the early spring of 1949. Although there was little grass until midsummer, so little Ladino clover became established that the plot was again disked and reseeded in August.

A sodium chlorate weedkiller, Atlacide, was spread dry at 100 pounds per acre on the grazed two-acre plot (4S) in the late fall of 1948 and Ladino clover seeded at 2 pounds per acre in the early spring of 1949. In contrast to some results on small plots, little of the grass was killed and scarcely any Ladino clover was seen during the season.

The birdsfoot trefoil seeded in 1943 on still another grazed two-acre plot (9S) seems to be slowly increasing and was quite noticeable during the very dry summer months of 1949. It afforded little grazing, however, as evidenced by the fact that the production of this plot was practically the same as similarly fertilized but unseeded pastures.

The studies of weedkillers for eliminating grasses so as to establish clovers without tillage are being continued on small plots, but there are no different results to report.

PASTURE RENOVATION EXPERIMENTS

Title: Date of Seeding Legumes, Grasses, and Weeds

Leaders: For Vermont Agricultural Experiment Station - A. R. Midgley and K. E. Varney
For the Pasture Research Laboratory - V. G. Sprague

At Burlington, Vermont

Seedings of 9 legumes, 7 grasses, and 14 weed species were made at four different seeding dates (December, March, April, and May). The objective was to ascertain whether weeds would offer less competition to forage grasses and legumes when early seedings were made. One year's data showed that grasses in general produced more forage, by midsummer, when planted in December or early March than when seeded in April and May. The legumes, on the other hand, had a

very high mortality with the December and early March seeding, much of it due to "damping off". However, the plants that survived were ahead of later plantings. The weeds were variable, but most of them did not grow until the soil and weather conditions were good. Some marked exceptions and variations occurred with all the plants used and additional data are being obtained over a period of years.

At State College, Pennsylvania

Germination and growth responses of weeds and forage species to different temperatures and day lengths are also being studied under controlled conditions for comparison with field responses.

Germination studies were conducted on blotting paper in petri dishes to determine the responses of five weed species and seven forage species to constant and alternating temperatures between 5°C and 30°C. The weed species included purslane, ragweed, crabgrass, yellow foxtail and buckhorn. The forage species included timothy, orchard grass, bromegrass, reed canarygrass, meadow fescue, Birdsfoot trefoil and zig-zag clover. In general, weed species required a higher temperature for germination than forage species, but species differences were also evident.

Purslane, buckhorn and crabgrass germinated well at constant or alternating temperatures between 20° and 30°C., whereas ragweed required alternating temperature for germination, and wider ranges between day and night temperatures were more effective. Most grass species germinated best at temperatures between 15° and 25°C, although bromegrass, reed canary grass, and meadow fescue germinated better at alternating temperatures between 10° and 20°C. than at 25° or 30°C. Legumes required somewhat higher temperatures for germination than the grasses showing no germination at 10°C or below.

Title: Evaluation of grasses and legumes for hay, silage and pasture

Leaders: For the Pennsylvania Agricultural Experiment Station - P. H. Margolf, J. B. Washko and E. W. Callenbach
For the Pasture Research Laboratory - V. G. Sprague

Experiment I: Evaluation of an orchard grass turkey pasture under two systems of grazing management, differing in intensity.

The fifth successive year for pasturing the two-acre areas of orchard grass began May 18, 1949 and continued until October 20, 1949. Two groups of White Holland turkeys hatched on March 8, 1949 and consisting of 175 and 350 poults each were used to graze the two areas. All equipment, shelters, feeders, and waterers were moved daily and each area grazed required approximately three weeks for a rotation. A turkey growing mash mixture, whole oats, wheat, corn, and oystershell were fed separately in outdoor hoppers.

The turkeys were 12 weeks of age when placed on these areas and were removed when 32 weeks old. Normal growth was obtained from both groups. The average body weights were 23.3 and 23.1 for the males and 12.4 and 12.6 for the females in the low and high intensity grazed areas, respectively.

The ratio of males to females was about equal in both groups. Total body weights and feed consumed for each area are given in Table VI.

TABLE VI

Concentrate Feed Consumed and Body Weights of Turkeys on Orchard Grass Range

No. of turkeys per acre	Total Body Weight in Lbs. Per Acre			Lbs. Concentrate Feed Consumed	Lbs. Concentrate Fed per Lb. Gain in Weight
	May 18	October 20	Increase		
87	293	1399	1107	6,668	6.02
175	590	2781	2191	12,356	5.64

It is interesting to note that on the range stocked with 175 turkeys per acre, 5.64 pounds of concentrate were required to produce a pound gain in body weight whereas where one half the number of birds ranged over a similar area 6.02 pounds of concentrate were required to produce the same gain. One possible reason for this lower grain consumption and apparent increased consumption of grass on the heavily populated area is that on this area little old forage remained and new growth was readily available to the turkeys whereas on the other range, a rather heavy accumulation of orchard grass leaves were trampled to the ground so that new growth was covered by the old leaves and was made less available.

Actual mortality and culling for each area was approximately 11 per cent. This suggests that 150 turkeys per acre may be grown successfully on an orchard grass pasture for five successive years, provided management practices are followed similar to those used in this experiment.

Experiment II: Terminated in 1948.

Experiment III: Carrying Capacity of Individual Species of Grass and Legume for Turkeys on Pasture

Grazing trials with turkey poults were initiated in 1949 on one-acre ranges, replicated three times, on each of the following species: Ladino clover, smooth bromegrass, Kentucky bluegrass, orchard and reed canary grasses.

One replication of all species was grazed from June 2, 1949; the other ranges were not available until August. Thus, while data for all ranges are not available for 1949, the results obtained from one replication and parts of others indicate differences in the carrying capacity of these several forage species. While 75 turkeys were started on each area, during August it was necessary to reduce the number on the Ladino and the bromegrass areas and to increase the number on the Kentucky bluegrass and the orchard grass. The birds on all areas were fed and managed similarly to those in experiment I, with the exception that the number of birds was varied according to the amount of forage available from the several species.

To determine the amount of standing forage, each range was sampled prior to stocking and before starting a new grazing rotation. These samples were sub-sampled to determine dry matter, protein and crude fiber.

During 1950 all ranges in the three replications will be grazed throughout the season to determine carrying capacity of the ranges, gains in body weight of the turkeys, and the saving of concentrate feeds.

MAINTENANCE OF LEGUMES

With Cornell (New York), Maryland, New Jersey, New Hampshire, Pennsylvania, Storrs (Connecticut) and The Division of Soil Management and Irrigation.

Title: The relation of soil properties to the persistence of perennial legumes.

Many of the alfalfa fields that were sampled for chemical analyses in 1948 (1948 Annual Report, pages 23 and 24) were inspected this year and soil cores taken for determination of volume weight and pore size distribution. In a number of fields 3 to 5 year old stands of alfalfa that were good in 1948 were poor in 1949. This severe reduction in stand of alfalfa appeared to be due to diseases, particularly bacterial wilt. Many plants had been killed and in others the roots were in varying stages of decomposition. These observations together with the results of the soil studies indicate that maintenance of good stands of alfalfa beyond about three years is dependent upon the use of disease resistant varieties as well as upon adequate lime and fertilizer and good soil drainage.

Chemical analyses to date show wide variations in available phosphorus and to a lesser extent in exchangeable potassium and in percentage potassium saturation. Both phosphorus and potassium average higher where alfalfa was good than where it was poor. Moreover, where comparisons can be made of good and poor stands of alfalfa on similar soils, often in different parts of the same

field, exchangeable potassium usually is higher where the alfalfa is better. Except in a relatively few cases soil acidity does not appear to be a limiting factor. As noted in the 1948 Annual Report, however, the survey was confined to areas where it was believed that lime was generally adequate. Soil tests indicate little if any relation between either exchangeable magnesium or organic matter content and persistence of alfalfa. Similarly, differences in volume weight and pore size distribution in the soils studied are not associated with persistence of alfalfa.

RUNOFF FROM PERMANENT PASTURES IN PENNSYLVANIA

Leaders: R. B. Alderfer for the Pennsylvania Agricultural Experiment Station
R. R. Robinson for the Pasture Research Laboratory and Division of Soil Management and Irrigation.

Investigations were made of runoff from 32 permanent pastures on five soil types in five counties in Pennsylvania. The soils were Gilpin, Glenelg, Hagerstown, Westmoreland, and Penn. All soils were silt loams or silty clay loams. In order to minimize the effect of differences in vegetative cover, the study was confined to areas that were rather closely grazed. On the basis of botanical estimates and plant vigor, 19 of the 32 plots selected for study were rated good to excellent, 8 were medium, 4 were fair and 1 was poor. Kentucky bluegrass and white clover were the predominant species on all except 3 of the pastures.

Water was applied with a type F rainfall simulator at a rate of 1.5 inches per hour to plots 6 x 12 feet, and runoff determined for a period of one hour. Because of differences in initial soil moisture content, a second or wet run was made about 24 hours after the initial run.

Soil cores from the surface soil layer and at depths of 2 and 4 inches were taken with a Lutz sampler for determinations of volume weight and pore size distribution. Samples were also taken for organic matter determinations. Porosity was determined by saturating the core and determining pores drained at tensions of 5, 50 and 100 centimeters of water. On selected cores, porosity was determined at tensions of 300 and 1000 centimeters.

The data on runoff show that the various sites varied widely not only in total runoff but in distribution of water loss during the period of simulated rainfall. Runoff for the 60 minute period of the initial run ranged from 5 to 74 per cent of the water applied with an average of 23 per cent. For the wet run, the range was from 4 to 73 per cent with an average of 33 per cent. On Glenelg and Hagerstown soils and particularly on the Penn, runoff was greater during the wet run than during the initial run.

On Gilpin and Westmoreland soils, however, runoff usually was no higher during the wet run than during the dry run. In a few cases, particularly site No. 18 on Westmoreland soil, runoff was much less during the wet run than during the dry run. This soil, which had not been tilled for many years and was very high in organic matter, showed unusual resistance to wetting.

The greater water loss during the initial run occurred on site 19, (Westmoreland soil) where within 10 minutes 79% of the water was running off the plot. No further increase in percentage runoff was obtained on this plot even during the wet run. On site 22 on Penn soil, on the other hand, runoff started at a very much slower rate but gradually increased to 100 per cent before the end of the wet run.

Thus it would appear that in some cases runoff is determined largely by conditions at or very near the soil surface, whereas in others, either the surface layer is not the critical one or the permeability of the surface soil decreases following wetting.

With the possible exception of the Penn soils, however, it is believed that the critical zone for moisture penetration in the soils studied is within 4 or 5 inches of the surface. Often this layer showed varying degrees of platiness. In some cases, particularly where the sod was heavy, the immediate surface to a depth of less than one inch would be well granulated, but the 1 to 4 inch layer would show marked platiness.

No satisfactory relation was obtained between runoff and volume weight or pore size distribution. In these soils differences in pore size distribution probably are of minor importance as compared with differences in orientation and continuity of pores. Although noncapillary porosity as measured by the pores drained between saturation and a tension of 50 centimeters of water ranged from 2.6 to 19.7 per cent, 43 per cent of the soils showed values for noncapillary porosity of 8 to 12 per cent. Thirty per cent of the soils had less than 8 per cent noncapillary porosity and 17 per cent had over 12 per cent. The volume of pores drained between 50 and 100 centimeters of water was generally between 1 and 3 per cent. Unfilled pores at saturation (assuming 2.65 for the specific gravity of the soil) usually were between 3 and 6 per cent.

These investigations indicate the need for further studies of infiltration capacity and physical properties of soils used for pasture production. In many soils, the compaction resulting from tramping by cattle during wet weather appears to be a serious factor even on good sods.

SOIL FERTILITY AND SOIL MOISTURE IN GRASSLANDS (WITH DELAWARE, MAINE, NEW JERSEY AND RHODE ISLAND)

Leaders: For the Delaware Agricultural Experiment Station - Leo J. Cotnoir, Jr.
For the Maine Agricultural Experiment Station - C. H. Moran, W. C. Libby, Stanley Junkins (J.S. Hardesty and S. Von Day, Soil Conservation Service)
For the New Jersey Agricultural Experiment Station - E. R. Purvis, W. A. Mitcheltree (G.A. Quackenbush, Soil Conservation Service)
For the Rhode Island Agricultural Experiment Station - H. C. Allbritten, Irene H. Stuckey and Milton Salomon.
For the Division of Soil Management and Irrigation and the Pasture Research Laboratory - R. R. Robinson

The objective of this investigation is to determine soil fertility levels and certain soil moisture relations in soils used primarily for hay and pasture (1948 Annual Report, pages 24, 25). Progress to date has been limited to soil fertility phases of the program.

At Delaware

Soil samples were taken from a number of selected farms in New Castle County. Additional farms will be sampled in the spring of 1950. No results are yet available.

At Maine

Soil samples were taken and records of fertilization and cropping practices obtained on 19 dairy farms. Laboratory analyses have not been completed.

At New Jersey

Most of the laboratory analyses have been completed on the soil samples taken the previous year. Although tabulations of the data have not been completed, it is apparent that as compared with the samples from Rhode Island (Table VII) the New Jersey samples are much higher in magnesium but very much lower in available phosphorus.

At Rhode Island

The soil samples collected last year from Washington and Kent counties were analyzed for pH, calcium, phosphorus, potassium, magnesium and organic matter. Table VII summarizes some of the results obtained. The 64 samples from the 0 to 3 inch depth in grasslands include 24 from permanent pastures, 7 from semi-permanent pastures and 33 from meadows. The soil tests showed relatively little difference between pastures and meadows except in acidity and in distribution of organic matter. Seventy-two per cent of the 0 to 3 inch samples from meadows had pH values above 6.0 as compared with only 4 per cent for permanent

pastures. Organic matter (not shown in the table) averaged 6.61 and 4.21 per cent respectively in the 0 to 3 inch and 3 to 6 inch depths of permanent pastures as compared with values of 5.67 and 4.64 per cent for meadows. Thus, permanent pastures are higher in organic matter than meadows in the surface three inches but lower at a depth of 3 to 6 inches.

The average for all soils from grassland given in Table VII shows that 47% of the samples from the 0 to 3 inch depth test higher than pH 6.0 and 77% are above pH 5.5. At depths of 3 to 6 inches, and particularly at 6 to 12 inches, the soils are more acid than at the surface. In general, the cropland soils are more acid than the 0 to 3 inch layer of grassland soils, but less acid than the 3 to 6 inch layer. Calcium content follows the same general pattern as pH values.

In evaluating the results of the phosphorus test, it should be noted that the method used gives relatively low values for phosphorus. In most soils, for example, the values obtained by the modified Truog method are about 10 times as high as those reported in the present study. Thus, the average value of 13.9 pounds of phosphorus per 2 million in the surface layer appears to be well above the minimum required for grassland production. The available phosphorus content decreases rapidly with increasing depth and at the 6 to 12 inch depth over 50% of the soils test less than 1 pound of phosphorus per 2 million. As in the case of calcium, the cropland averages lower in phosphorus than the 0 to 3 inch layer of grassland soils, but higher than the 3 to 6 inch layer.

Exchangeable potassium averages 137, 48 and 26 pounds per 2 million respectively in the 0 to 3, 3 to 6, and 6 to 12 inch layers in grassland soils. The plow depth of the cropland averages 159 pounds of potassium.

The values obtained for magnesium average only about 8% as high as those for calcium, but show a similar trend in regard to distribution. The average results show the highest values for magnesium in the 0 to 3 inch samples from grassland. Sixty-seven per cent of these samples test over 100 pounds of magnesium, as compared with only 38% for cropland.

Narragansett and Merrimac soils comprise 78 per cent of the total samples. These two soils showed marked differences in available phosphorus. Fifty per cent of the samples of Merrimac soil tested over 20 pounds of phosphorus per acre whereas only 2 per cent of the Narragansett soils exceeded this value. The extent to which this may have been due to past fertilizer practices cannot be determined from the data obtained. There is little relation, however, between the results of soil tests and data obtained from farmers of the amounts of fertilizer or of fertilizer and manure applied during the past five years.

At the time the soil samples were taken the grasslands were rated excellent, good, medium, fair, poor, or very poor. The soil tests showed that 75 per cent of the good and excellent sods were on soils with pH values above 6.0 whereas only 7 per cent of the poor ones were in this class. Similarly 92 per cent of the good and excellent sods have more than 1600 pounds of calcium per 2,000,000 as compared with 7 per cent for the poor pastures. Eighty-four per cent of the better sods test more than 4 pounds of phosphorus as compared with 17 per cent for the poor pastures. Ninety-two per cent of the soils from good and excellent sods test over 120 pounds of magnesium, whereas only 13% of those from poor sods test this high. Potassium, on the other hand, averages no higher on good sods than on poor ones.

Field experiments to determine the responses to fertilization on selected soils are being planned.

TABLE VII
Nutrient Availability in Soil Samples from Rhode Island

Land Use & Depth of Soil Sample	No. of Samples	Average Nutrient Level	Percentage Distribution of Samples According to Nutrient Level				
			pH Value				
			4.0 to 4.5	4.5 to 5.0	5.0 to 5.5	5.5 to 6.0	6.0-7
Croplands (0-6")	16	-	-	13	13	44	31
Grasslands(0-3")	64	-	2	3	19	30	47
Grasslands(3-6")	57	-	-	12	33	28	27
Grasslands(6-12")	54	-	-	9	43	26	22

			Calcium, pounds per 2 million					
		Ca,#/2 million	Tr	Tr-500	500-1000	1000-2000	2000-3000	Over 3000
Croplands (0-6")	16	1423	-	6	31	38	25	-
Grasslands(0-3")	64	2138	2	6	17	28	28	19
Grasslands (3-6")	57	1100	11	14	28	35	12	-
Grasslands(6-12")	54	467	20	37	33	9	-	-

			Phosphorus, pounds per 2 million						
		P,#/2 million	Tr	Tr-1	1-2	2-5	5-10	10-20	Over 20
Croplands (0-6")	16	10.5	-	-	13	25	31	19	13
Grasslands (0-3")	64	13.9	-	-	5	37	17	23	17
Grasslands (3-6")	57	4.6	14	4	30	25	16	9	4
Grasslands (6-12")	54	1.2	44	9	26	17	4	-	-

			Potassium, pounds per 2 million					
		K,#/2 million	Tr	Tr-25	25-50	50-100	100-200	200-400
Croplands (0-6")	16	159	-	-	-	25	63	13
Grasslands (0-3")	64	137	2	-	14	27	34	23
Grasslands (3-6")	57	48	32	18	23	11	16	2
Grasslands (6-12")	54	26	44	19	24	6	7	-

			Magnesium, pounds per 2 million					
		Mg,#/2 million	Tr	Tr-25	25-50	50-100	100-200	200-600
Croplands (0-6")	16	109	-	19	13	31	19	19
Grasslands(0-3")	64	187	-	2	12	19	39	28
Grasslands(3-6")	57	87	4	16	33	11	32	6
Grasslands(6-12")	54	43	19	37	22	13	7	2

Phosphorus, potassium, and magnesium were determined by the modified Morgan procedure, essentially as outlined by Peech and English (Soil Sci. 57: 167-195).

PART II

RESEARCH AT THE LABORATORY

CYTOGENETICS AND BREEDING

Varietal Improvement in Dactylis glomerata and Trifolium repens

Inbreeding in Orchard Grass: A randomized block experiment consisting of six replications of 72 plots each was planted in the spring of 1948, using polycross seed from 52 I_4 lines, representing 19 families, and from each of the 19 parental clones plus a commercial check (1948 Annual Report, page 26). During the summer of 1949, three replications were harvested for hay at the early bloom stage and subsequently clipped twice to simulate pasture. The remaining three replications were harvested during the season to simulate pasture. Nitrogen fertilizer at the rate of 60 pounds per acre was applied in the early spring and at 40 pounds per acre after each of the first two clippings.

At the individual harvest dates for the hay and pasture treatment, it was found that there were 16 comparisons in which the I_4 polycross progenies yielded significantly less than the corresponding parental progeny. There were 7 comparisons in which the I_4 lines produced significantly higher yields than their parental lines. In that portion of the experiment harvested for pasture alone there were 23 comparisons in which the I_4 progenies yielded significantly less and 24 comparisons where they yielded significantly more than their parental lines.

When the total seasonal production was considered for the hay + pasture treatment, 2 I_4 lines were significantly better than the corresponding parental progenies and 5 were significantly poorer. Under pasture alone, 6 I_4 lines were significantly better and 2 were significantly poorer. Within some families all I_4 lines gave consistently better yields at all harvest dates when compared to the progeny from the parental clone, while in other families they were consistently poorer. The preliminary information furnished by this trial suggests that within certain families it may be possible to select inbred lines that are superior to the parental clone in general combining ability.

In order to obtain further information on the effect of inbreeding on combining ability, 372 plants were brought into the greenhouse for crossing. This material represents 36 I_5 lines from 14 of the 19 families used in the above experiment, together with the 14 parental clones and two testers (an unrelated I_5 clone and a selected open pollinated clone). Seed produced from these crosses will be planted in the spring of 1950. Bagged seed was obtained from I_5 progenies (1948 Annual Report, page 26) to continue the study.

Comparison of Clonal, Polycross and Single Cross Progeny Tests for the Evaluation of Individual Plants of Dactylis glomerata. Additional information is required with respect to the comparison between clonal and polycross progeny tests (1948 Annual Report, page 26). A new experiment was set up to compare the combining ability of selected orchard grass lines as measured by progenies representing 3 different sources, (a) a large polycross consisting of 112 clones planted in 6 replications of 5 plants each (b) restricted polycrosses planted with 15 to 25 replications of 10 plants each, and (c) single crosses obtained by interplanting 2 twenty plant rows under isolation in wheat fields.

The material selected for this study consists of the 7 clonal lines which constitute restricted polycross #1, average maturity 5/31, and the 5 clonal lines included in restricted polycross #5, average maturity 6/11. Thirty-one single cross plots (wheat field isolations) representing all possible combinations of the 7 clonal lines within polycross #1 and all combinations of the 5 within polycross #5 were available. Single cross seed was supplemented by bagging panicles in adjacent rows in the two restricted polycrosses. In the summer of 1949 seed was collected from each clonal line and threshed separately. In addition, seed was collected from the 12 selected clonal lines in the large polycross of 112 clones.

The progenies of the 7 clonal lines in the early maturity group will be planted in the spring of 1950 in a randomized block design with 4 replications. Each replication will include the following: 7 clonal plots representing the parental lines, 7 plots for progenies from the large polycross, 7 from the restricted polycross, 21 representing all possible single crosses and one plot of composite seed from the restricted polycross.

In order to examine more carefully the variation within the different sources, both spaced plants and broadcast plots will be used to evaluate the progenies of the 5 clonal lines in the late maturity group. This experiment will be planned to provide the same comparisons that have been outlined above for the 7 early clonal lines. The individual plants will be harvested separately. The response of the progenies in the broadcast plots will be compared with the spaced plants, and the number of plants needed to typify a progeny will be estimated.

Selection for Persistency in Trifolium repens. The persistency of Ladino clover is probably influenced by a number of factors including disease, adverse climatic conditions and management. There may be some question whether selection as practiced in space-planted nurseries is the most effective way to screen large populations for plants exhibiting superior persistency. For example, it has been demonstrated that Ladino clover plants differ in their tolerance to low light intensity (page 49). The practical importance of this fact has yet to be demonstrated but it serves to illustrate the possible shortcomings associated with selection in spaced plantings.

A preliminary experiment was planted in the spring of 1949 to examine the behavior in the nursery (vigor and persistency) of spaced Ladino clover clones from the low light intensity study. The treatments include no companion species, seeded with a late strain of orchard grass and seeded with early orchard grass, in all combinations with two clipping schedules (clipped to simulate pasture and clipped for hay and pasture).

Isolation of Ladino Clover Plants Resistant to Sclerotinia trifoliorum. All clones that showed relatively good survival in previous greenhouse tests were retested in the fall of 1949 (1948 Annual Report, page 28). The material available for this work consisted of 175 clones selected as follows: 79 representing commercial Ladino clover from various sources, 18 from the 103 clones in the 1947 polycross test, 52 from the 228 Ladino clover selections made in 1947 and 26 from polycross seed harvested from individual clones in the 1947 polycross test.

The tests conducted in 1949 were designed to be as comprehensive as facilities would permit. The 79 clones from commercial Ladino were inoculated in 2 replications of approximately 25 plants each. All other sources were tested in 4 replications of approximately 25 plants each.

Although the previous screening tests eliminated a large percentage of the susceptible clones, many of the clones selected for the 1949 tests proved to be susceptible. Increasing the number of plants per replicate provided a satisfactory basis for discarding a large number of questionable lines. No immune plants have been isolated to date. At least 17 plants appear to be moderately resistant and an additional 25 seem promising. Promising lines have been arbitrarily selected on the basis of 50% healthy survivors, while an average of 60% or above indicates moderate resistance. The average number of healthy plants in the susceptible checks was 24%.

The heavy inoculation that is possible under greenhouse conditions should be effective in isolating superior plants. In an attempt to test this effectiveness, the moderately resistant plants, together with representatives from the susceptible classes, will be planted in clonal plots in the spring of 1950. These plots will be inoculated in the fall of 1950 to determine the validity of classes assigned in the greenhouse.

Genetic Investigations

Inheritance of maturity in Dactylis glomerata. Seed obtained from crosses made in the greenhouse during the winter of 1947 (1947 Annual Report, page 28) was planted in the spring of 1949. Three series are involved in this experiment and each series was planted according to a randomized block design with 10 spaced plants per plot and 8 replications. In series I there are 27 plots per block, 7 of which were started from tillers and 20 from seed. The vegetatively propagated plots include one plot of the early maturing

parental clone, one plot of the late maturing parental clone and 5 plots of the F_1 clones that were used in the production of F_2 and backcross progenies. The seedling plots include one F_1 plot, 5 plots of the backcross - F_1 onto the early parent, 5 plots of the backcross - F_1 onto the late parent and 10 F_2 plots. Series II involves crosses between another late clone of orchard grass and another early clone. There are 32 plots per block which consist of the same generations outlined for series I. The two early clones which occur in series I and II were used as the parental clones for series III. There are 45 plots per block in series III, and the generations are similar to those employed in the first series.

In addition, a group of 34 miscellaneous crosses between late and early clones was planted in order to study the recombination of desirable characters. These progenies were set out in 5 replications of 10 plant rows.

Inheritance of Quantitative Characters at the Diploid and Tetraploid Levels in Dactylis spp. The species that will be used in this study are Dactylis aschersoniana and the Iran diploid which may be Dactylis hispanica (1947 Annual Report, page 34). These two species differ widely in the expression of several quantitative characters including maturity, size and shape of inflorescence, color, pubescence and others. Diploid parental clones of Dactylis aschersoniana and the Iran diploid will be used to produce F_1, F_2 and backcross generations. Tetraploid lines to be produced by treating the diploid parental clones with colchicine will then be crossed to obtain the same generations mentioned above for the original diploid parents.

At present, selected diploid parents are being treated with colchicine to induce tetraploidy. In addition, 300 plants were brought into the greenhouse in the fall of 1949 for crossing. Most of this work will be confined to the diploid level, although a few tetraploid clones were available and these will be used in an attempt to produce F_1 hybrids.

Inheritance of Male Sterility in Dactylis glomerata. Results obtained in 1947 from the classification of approximately 8,600 plants were not consistent with the hypothesis that had been advanced previously (1947 Annual Report, page 31). Observations made in the summer of 1949 indicate that the expression of certain classes may be influenced by environmental conditions. This appears to be the situation with respect to plants that are either partially male fertile or partially male sterile. With this in mind, 230 plants, representing 45 lines, which have behaved consistently with respect to degree of fertility or sterility were brought into the greenhouse for crossing. In addition, 12 clones were selected as examples of the 4 principle classes - complete male fertility, partial fertility, partial sterility and complete sterility. In order to obtain specific information on the effect of the environment prior to anthesis, these 12 clones will be subjected to four different series of alternating temperatures in the control chambers.

Inheritance of Anther Color in Dactylis glomerata. Plants were selected on the basis of anther color from the F_2 nursery established to study the recombination of characters in orchard grass (1947 Annual Report, page 28). These plants fell into 5 main categories - bronze, purple, lavender, yellow and green. Plants possessing bronze and green anthers were readily classified, but a finer subdivision could be made within the remaining groups. Thus, purple faded to either rose or cream, yellow faded to either cream or to a bright yellowish cream, while lavender could be divided into pale and dark lavender. Altogether 395 plants representing these 8 subdivisions were brought into the greenhouse for crossing.

Inheritance of Immunity from Crown Rust in diploid Festuca elatior. Seed representing F_1, F_2 and backcross generations was obtained in the greenhouse during the winter of 1948-49 (1948 Annual Report, page 28). Seedlings started in the greenhouse in the fall of 1949 were subsequently inoculated with crown rust. The two immune parents, 247(1) and 247(2), that had been selected (1945 Annual Report, pages 48, 49) for this study were quite different in their behavior. For example, when 247(1) was crossed to a susceptible plant the reaction of the F_1 ranged from susceptible through intermediate and resistant to immune. On the other hand, the F_1 progenies resulting from the cross 247(2) x a susceptible were very largely susceptible and intermediate in reaction, with relatively few resistant plants and no immunes.

The ratios obtained to date suggest that several factors may be involved in the expression of immunity. Definite conclusions are not warranted, however, because of the limited number of plants involved in some of the critical progenies. 100 plants brought into the greenhouse in the fall of 1949 will be crossed to produce additional F_1, F_2 and backcross seed.

Inheritance of Leaf Coloration in Trifolium repens. Three principle types, purple leaf, purple midrib and purple fleck, were selected for this study. These characters require light for their expression, but observations would suggest that they react in a differential manner to light quality. Under incandescent lights, purple leaves fade very rapidly to green, purple midrib does not fade quite so rapidly, while purple flecking can be maintained over a longer period. The stability of these characters under incandescent lights apparently varies within groups. Representative clones of each group, together with some normal plants, were brought into the greenhouse in the fall of 1949 for observation and crossing.

Inheritance of Flower Color in Medicago sativa. Preliminary work has been undertaken to identify the pigments and to find procedures for rapid quantitative determinations. By using this approach it is hoped that the inheritance of flower color in Medicago sativa may be placed on a more satisfactory basis. 70 plants representing a rather complete range in flower color were brought into the greenhouse for chemical determinations.

Cytological Investigations

Origin of Aneuploidy in Dactylis glomerata. The material from crosses between plants with 29 chromosomes is in the process of being rechecked (1948 Annual Report, page 28). At present 596 plants, representing 38 progenies of crosses between 29 chromosome plants, have been re-examined with the following results: 318 appear to be euploid with 28 chromosomes, 4 have 27, 128 have 29, 25 have 30, 2 have 31, 1 has 42 and 1 was found to have 56 chromosomes.

The chromosome behavior of 15 of the 30 chromosome plants has been examined in an attempt to detect differences that might be associated with the presence of different chromosomes. No marked variations in chromosomal association were encountered.

In the fall of 1949, 52 representatives of 10 aneuploid series were brought into the greenhouse for morphological studies.

Polycross Tests of Hexaploid Dactylis glomerata. Seed was collected in the summer of 1949 from the hexaploid polycross established in 1948 (1948 Annual Report, page 28). Examination of this material has shown that at least three of the 24 clones involved are tetraploids. Fifteen hexaploid plants had a range in mean multivalent frequency in microsporocytes of 2.07 to 4.19, the frequency of sporocytes with lagging univalents at Anaphase I ranged from 21.2 to 72.5 per cent. The percentage of quartets showing micronuclei ranged from 32 to 68.4 per cent.

As this nursery was planted adjacent to tetraploid orchard grass, collections were made to determine the amount of natural crossing between the hexaploid and tetraploid strains. Chromosome determinations will be made within progenies of plants located near the center and near the border of the polycross block.

Hybridization of Lolium perenne by Festuca elatior. Seed produced in the winter of 1948-49 (1948 Annual Report, page 30) from crosses between Lolium perenne and Festuca elatior at both the diploid and tetraploid levels is being grown. This material will be examined for possible hybrids. Judging from past experience, the production of hybrids between tetraploid clones of Lolium perenne and Festuca elatior will prove difficult. One hundred thirty-eight plants were established in the greenhouse in the fall of 1949 to attempt additional crosses. Hot water emasculation will be used as well as mutual pollination.

Interspecific relationships in Bromus spp. A study of interspecific hybridization between related species of the genus Bromus was initiated in the winter of 1948-49 (1948 Annual Report, page 30). A limited quantity of seed obtained from crosses made in the winter of 1948-49 is being grown and examined for possible hybrids. Production of interspecific hybrids within this genus is complicated by the high self fertility of the species in the present collection. In addition, several species possess cleistogamous flowers.

In an attempt to overcome these difficulties, an extensive program of hot water emasculation has been planned for the winter of 1949-50. The material selected for this study includes 12 species belonging to the section Bromopsis, 7 to the section Bromium and 2 to the section Ceratochloa.

Interspecific and Intergeneric Hybridization in the Leguminosae. Self sterile clones of Trifolium pratense and Trifolium repens were used as female parents in crosses with 25 species of Trifolium, 12 species of Medicago, 4 species of Melilotus, 2 species of Trigonella and 1 species of Parochetus. Seed formation occurred in several of the crosses involving T. repens, but where T. pratense served as the female parent no seed was obtained. The species that gave some seed when crossed with T. repens are as follows: T. alexandrium (52 seed), T. arvense (8), T. dubium (1), T. hybridum (2), T. incarnatum (19), T. lappaceum (1), T. nigrescens (81), Medicago arabica (5), M. obscura (21), M. scutellata (4), and Melilotus suaveolens (9).

Examination of the survivors has not been completed but at least one plant, from the cross T. repens x T. nigrescens, appears to be a hybrid. Further hybridization work with these species is in progress.

PATHOLOGY

Studies with Sclerotinia Trifoliorum

Several phases of the work on S. trifoliorum previously noted (1948 Annual Report, pages 28, 35-36) were continued.

Selecting for resistance to Sclerotinia trifoliorum in Ladino clover (See page 41 under Part 2).

Selecting for resistance to Sclerotinia trifoliorum in red clover. (See page 22 under Part 1).

Degeneration in S. trifoliorum.

Three of the ten monoascospore isolates with "fresh" and "degenerate" counterparts were selected for further study. In order to maintain them in a stable form, these isolates have been transferred at frequent intervals to fresh culture media and after 70 passages are still stable. The "degenerate" cultures have shown no indication of recovering their original rapid rate of growth or their capacity to produce sclerotia.

When "fresh" and "degenerate" counterparts of ten monoascospore isolates were grown on ten different culture media, the relative difference in rate of growth between "fresh" and "degenerate" cultures was maintained on most of the culture media. Sclerotia were formed only by "fresh" isolates and not by any of the "degenerate" isolates regardless of culture medium used. This suggests that nutrients insofar as supplied by the culture media tested cannot restore "degenerate" cultures to normal growth.

In order to determine what effect aging of cultures had on the degeneration phenomenon, "fresh" isolates from serial platings on potato-dextrose agar were stored at 15°C and at room temperature. Sub-transfers from the serial platings made at 5 day intervals demonstrated that "fresh" cultures 10-20 days old were starting to show signs of degeneration as manifested by slower growth of the sub-transfers as well as reduced production of sclerotia. This resulted regardless of whether the cultures were incubated at 15°C or at room temperature.

When subtransfers were made at 2-day intervals from "fresh" isolates stored at 15°C for aging, growth but not sclerotia production was retarded after 14 days.

"Fresh" and "degenerate" counterparts of the same isolate were plated opposite each other in the same Petri dish of potato-dextrose agar. The rates of growth of the "fresh" and "degenerate" counterparts on the same plates were similar to those obtained when each was grown separately. When the colonies approached each other from opposite sides of the same Petri dish there was in some cases a distinct depressing effect of the "degenerate" colony on its "fresh" counterpart. In some cases there was a distinct clear zone delimiting the junction between "fresh" and "degenerate" colonies. However, when two "fresh" colonies of the same or of different isolates grew in the same Petri dish the zone where junction occurred was not so noticeable.

Further studies are underway to determine the factor or factors that induce degeneration and whether degeneration can be forestalled or counteracted.

The Longevity and Virulence of Sclerotinia Trifoliorum Inoculum Prepared from Cultures Grown on Grain. Large quantities of inoculum of the crown rot fungus, Sclerotinia trifoliorum have been required for field and greenhouse tests to discover resistant forage legumes. Dried grain inoculum has offered certain advantages over other methods tested namely, ease of application, preparation and storage of large amounts at the convenience of the investigator, and availability of inoculum when plants are at the proper stage for testing. To date, several bushels of inoculum have been prepared and used to inoculate either individual plants in the greenhouse or sizeable areas of plants in the field.

The pathogen was readily grown on a steamed mixture of 2 parts wheat one part oats in 250 ml. Erlenmyer flasks. Maximum growth was obtained after 3 weeks' incubation at 15°C. The fungus-infested grain inoculum was then dried at room temperature, ground, and stored at 5°C. When some of the dried grain inoculum was placed in contact with the crown of a susceptible plant it usually killed it in 7 to 15 days.

Preliminary tests showed that the degree of fineness to which the inoculum was ground influenced its capacity to attack plants. Inoculum that passed through a 40-mesh screen failed to grow or attack plants while coarser inoculum readily killed plants when tested under similar conditions. Large quantities of dried grain inoculum ground in a hammermill through a 1/4 inch screen have remained viable and virulent for long periods.

Samples collected from different batches of inoculum prepared during the period 3/25/47 to 9/16/49 were stored at 5°C and tested periodically for viability and pathogenicity to red and Ladino clovers. No deterioration of the inoculum was found in a test conducted 2/1/49 when the oldest sample had been stored 23 months. In a later test conducted 12/7/49, with older plants of red clover, the samples prepared in March 1947 were only slightly less potent than those prepared more recently. From these results, it was concluded that dried grain inoculum of Sclerotinia trifoliorum could be prepared and stored at least one year to provide a uniform source of inoculum for experimental work during that period.

Field Tests:
During March of 1948, an area was sown to Ladino clover and Ladino clover plus orchard grass for the purpose of determining pathogenicity of S. trifoliorum to Ladino clover under field conditions involving different treatments. The Ladino clover and Ladino clover plus orchard grass areas were each divided into 32 plots of 4 x 16 feet in linear arrangement.

One clipping to 2-1/2 inches was removed from all of the plots on July 7 and another on September 22. A late fall cut was removed from 16 of the 32 plots in each area on November 5. Each of these blocks of 16 plots was in turn subdivided into blocks of 8 plots which were to be mulched with straw or left unmulched. On November 12, 1948 4 plots at random within each block of 8 were inoculated with S. trifoliorum, the remaining 4 plots in each block were not inoculated. Inoculation was accomplished by scattering evenly by hand approximately 1000 cc of dried grain inoculum within the confines of each plot. The inoculum was grown on a wheat-oats mixture several weeks previously and comprised 10 pathogenic monoascospore isolates. Immediately after inoculation fresh straw was scattered to a depth of several inches over plots to be mulched.

The subsequent winter months were largely free of snow until January and February. The temperature dropped below 10°F several times but for the most part the winter was open and relatively mild. In March extremely mild temperatures occurred and the straw mulch was removed on March 29, 1949. Both unmulched and mulched plots that were inoculated with S. trifoliorum were practically wiped out with a sharp line of demarcation between inoculated and adjacent non-inoculated plots. It made no difference whether Ladino clover was sowed alone or with orchard grass. There also was no apparent difference in plots that received a late fall clipping and those that were not clipped.

Dead and dying stolons covered the ground in inoculated plots that were not mulched. The mulched plots were almost bare as though infection had occurred shortly after inoculation and the dead stolons had largely disintegrated. However, there appeared to be more surviving crowns or stolon buds in the mulched plots. This was more evident later in the season when it was possible to determine how much surviving clover remained.

Examination of inoculated plots showed that abundant sclerotia were formed on and in dead and dying stolons. The surface of the ground in inoculated plots was heavily populated with sclerotia. When dead crowns were dug, sclerotia were found attached to dead and dying roots several inches below the surface of the soil. In some cases where infection had spread into the border at the ends of inoculated plots, flaccid stolons with immature sclerotia and fluffy masses of mycelium were encountered. Periodic examination during spring and early summer showed that there was still some active infection by Sclerotinia as late as July 21, apparently either from internal mycelium reactivated by short periods of cool wet weather or from germinating sclerotia.

Throughout the remainder of the 1949 growing season the plots were clipped and otherwise handled for best advantage to the Ladino clover. No further inoculation is contemplated on these plots but the mulching and clipping treatments will be continued and observations made on possible spread of the disease and recovery of the clover.

Investigations on Fusarium wilt of red clover and other forage legumes (see page 20 under Part 1).

Inheritance of resistance to crown rust in meadow fescue (see page 43 under Part 2.)

PHYSIOLOGY AND BIOCHEMISTRY OF PASTURE PLANTS

Growth responses of Ladino Clover Clones under Low Light Intensities

Ladino clover grown in association with a tall growing grass must compete for light as well as for moisture and plant nutrients. Light intensity at ground level in a heavy stand of grass at the silage stage of growth is reduced by the grass from the 12,000 foot candle intensity in sunshine to about 125 foot candles. A preliminary experiment was set up to determine whether clover plants varied in their ability to survive under low light intensities.

Triplicate pots of about 125 clones of Ladino clover well established under greenhouse conditions were removed to artificial lights (white fluorescent) supplying an intensity of 150 foot candles at the soil surface. A similar series of replicates was allowed to continue growth in the greenhouse. Both series of plants were grown under a 16-hour day length.

The date of death of each plant grown under the low light intensity was recorded. The length of time various clones survived the low-light intensity ranged from 21 days to over 100 days. About half (67) of the clones were dead after 50 days, another third (45) died after 75 days, 15 plants survived to 96 days and 5 plants were growing at 100 days when the experiment was discontinued. From these results it was evident that wide variations existed between plants in their ability to grow under low light intensities. This did not appear to be closely associated with size of leaves when the clone was grown in the greenhouse but there was some indication that the smaller-leafed types of plants were better able to withstand low light intensity. Some of the clones that were infected with a clover virus were more severely injured by low light intensities than disease-free plants.

The experiment is being repeated in 1950 and to follow these tests further, field plots are being established to determine whether those plants better able to withstand low light intensity may also be more persistent when grown in association with orchard grass.

Plant Climate Studies

The major efforts during the past year have been placed on designing equipment to measure and record air movement and relative humidity. While this equipment is not yet complete, an anemometer circuit has been assembled which has been calibrated for measuring air velocities from less than 1/2 mile per hour to 20 miles per hour. The sensing element used is thermistor #D-176980 developed by Western Electric. This element is small, about 3/16 inch in diameter, is mounted on a glass rod 2 inches long, and can be placed between leaves or stems of growing herbage without disturbing the vegetation. The anemometer is extremely rapid in its response to changes in air velocity. It appears that one important use of this instrument will be to determine the relationship of air movement at 4 feet, where a cup-type anemometer can be used, with the movement at the top of a grass sward as well as air velocities at various heights above the soil surface within that sward. Preliminary data taken over a very short Kentucky bluegrass sward indicate that at 4 feet above this sod the air velocity was 8.5 miles per hour, at 1 foot 6.5 miles per hour, at 3 inches 1.5 miles per hour and at 1/2 inch it was 0.6 miles per hour. At the surface of a clump of bluegrass 3 inches high, the wind velocity was 1 mile per hour whereas 1/2 inch above the soil surface within this grass the wind velocity was only 0.2 miles per hour.

While the relative humidity recording equipment has not yet been tested under field conditions, it appears entirely possible to obtain relative humidity values from measurements of the dewpoint as measured with a lithium chloride sensing unit and a resistance thermometer. This unit is small enough to be inserted within a grass sward without seriously disturbing the growing herbage.

Temperature records taken the past year in State College have again indicated the wide differences in temperature existing at different heights above the ground surface. Temperatures at 4 feet and at 8 feet above a Kentucky bluegrass sod are very similar to those recorded by the U. S. Weather Bureau but at a 3-inch height the temperatures on a clear day are from 5 to 10 degrees higher than the official temperatures whereas on a clear night they may be 5 to 10 degrees lower. Soil temperatures 1/8 inch below the surface in a Kentucky bluegrass sod on a clear day exceeded by 20 degrees the air temperatures at 4 feet above the soil. Also, at night these soil temperatures remained 5 to 10 degrees above the air temperature at a four foot height.

It is becoming more evident that the climate under which plants exist and under which the diseases and insects that attack them grow is radically different from the climate as reported by the U. S. Weather Bureau.

Relationship Between Time of Orchard Grass Flowering in the Field and the Length of Day

Previous work has shown that plants of orchard grass vary in their responses to day length; some flower under a 13-hour day length, others require 15 or 16 hours of light each day to induce flowering. To obtain information on the relationship between day length and the observed earliness of orchard grass clones used in the breeding work 13 clones (8 "early" and 5 "late") were grown in the greenhouse under day lengths of 12, 12-1/2, 13, 13-1/2, 14, 14-1/2, 15, and 16 hours. Dates of heading (when the head was fully out of the boot) and flowering (anther dehiscence) were recorded. Of the 5 "late" clones used, only one flowered under day lengths shorter than 15 hours and this clone flowered under a 14-1/2 hour day length. Of the 8 clones designated as "early" in the field, 6 flowered at all day lengths above 12-1/2 hours, one more at 13 hours and one more at 14-1/2 hours. The elapsed time from the date when the increased day lengths were started to the heading or flowering date of the "late" clones was greater than that of the "early" clones growing under the same day lengths (14-1/2 to 16 hours). About 25 days were required by the "early" clones to reach the flowering stage whereas the "late" clones required 35 days. When the "early" clones were grown under a 13- or 13-1/2-hour day length, they required a longer time to reach the flowering stage - often 30 to 35 days.

It appeared from this experiment that the plant's response to length of day is an important factor contributing to the earliness or lateness of this plant when grown under field conditions.

Effects of Isopropyl N-phenyl Carbamate on Inhibiting Head Formation of Orchard Grass

Head formation of orchard grass has been shown to be decreased by the application of INPC to established plants (1948 Annual Report, pages 38-40). A similar experiment was conducted during 1948-49 on two fields, one in which orchard grass was growing in association with Ladino clover, and another in which a pure stand of orchard grass was used that was fertilized with nitrogen. Plots 4 x 8 feet in size were laid out in four replications on each field and several dates of application of INPC were used. On the orchard-Ladino clover area these included October 28, 1948, March 29, April 7, April 18, and April 28, 1949. On the pure orchard grass, three times of application included April 7, April 18, and April 28, 1949. Three rates of application were used in addition to a no treatment "check". These rates included 1 pound, 2 pounds and 4 pounds INPC per acre dissolved in water and applied with a sprinkling can. At the time the October and March applications were made, floral primordia of the grass were not visible by micro-dissection. On April 7 and 18 the floral primordia were 0.5 to 2 mm. long and by April 28 the primordia were one or two centimeters long. Nitrogen was applied at the rate of 60 pounds per acre to the pure orchard grass in March of 1949 and at forty pounds per acre again in May and July following the harvest. Both series of plots were cut May 27 when the orchard grass was in head and just prior to full bloom. Dry matter yields, percentages of leaves and stems, and botanical analyses of the herbage were made

The results of these trials indicated that application of 1# or 2 #/A of INPC in early spring reduced the number and size of the flowering stems and at the same time actually increased the amount of leaf growth. The 4-pound rate of application decreased the number of flowering stems to 6 or 8 on 32 sq-ft. but it also reduced leaf growth to a marked extent. The application of INPC made on April 28 when the flower primordia were one or two centimeters long reduced head formation slightly and only at the highest rate.

The first aftermath cutting taken July 20 was very surprising in that the areas receiving INPC in early spring produced more total growth than the untreated plots even though in the first harvest the INPC had reduced total dry matter production in all instances. A third harvest made September 26 showed no residual effects of any of the spring treatments. While there was some indication that treatment with INPC may have improved the growth of Ladino clover associated with the orchard grass, field variability was so great that the differences may not be highly significant.

The Responses of Dactylis glomerata-Trifolium Repens to Nitrogen Fertilization, Soil Moisture, and Clipping Treatments.

Orchard grass continued to produce high yields under irrigation and heavy fertilization. Plots receiving lime and phosphate plus 210 pounds of K_2O in three applications, and 280 pounds of nitrogen in six applications produced 9747 pounds of dry hay and aftermath per acre as compared with 9515 pounds last year (1948 Annual Report, pages 40 and 41). Very little Ladino clover persisted under this treatment. Under irrigation but without nitrogen fertilization, the orchard grass-Ladino clover mixture produced 6799 pounds per acre. Without irrigation, yields averaged 3913 and 6237 pounds per acre, respectively, for no nitrogen and high nitrogen fertilization. In general, yields averaged higher on plots clipped as hay and aftermath than on those clipped to simulate rotational grazing. This difference was most marked on plots receiving nitrogen fertilization.

The increase in yield from irrigation averaged about 3300 pounds per acre. This increase, however, involved 9 irrigations totalling 11 inches of water.

Rate and Frequency of Potash Applications on Dactylis glomerata-Trifolium Repens

Potash was applied at various rates and frequencies to plots of orchard grass-Ladino clover on Hagerstown silty clay loam. Yields of dry matter and percentage stand of clover were determined. Potassium determinations are being made of the mixed herbage. On selected plots, the grass and clover are being analyzed separately.

Because of dry weather together with rather low percentages of clover on the area, the yields were low during midsummer. Under these conditions, summer application of potash was not particularly effective.

PART III

PASTURE RESEARCH AT STATE STATIONS

STORRS (CONNECTICUT) AGRICULTURAL EXPERIMENT STATION

Title: Alfalfa Experiments

Leaders: B. A. Brown and R. I. Munsell

Results: During the first two harvest seasons (1947 and 1948) there was little to indicate a shortage of K where a three-year supply of potash (600 pounds per acre of 60% muriate of potash) had been applied before seeding in August 1946. In 1949, however, there was distinctly less growth on those plots than on those with annual applications of potash. In contrast, alfalfa grew equally well on plots which received all of their superphosphate in 1946 as on those with annual treatments. In 1947 and 1948, the average yield of all plots was 7500 pounds of dry matter per acre.

In an attempt to learn if high K-low Ca hay was responsible for the poor production of a dairy herd in eastern Connecticut, the Dairy Department conducted an experiment in which four groups of four lambs each were fed hays of widely varying potash contents and also potash salts in their grain. No appreciable differences were noted in the well-being of the lambs. Feeding trials are being continued with lambs and calves.

Of the five minor elements (B, Mn, Cu, Zn and Mo) applied in this experiment, only B has had any apparent effect. Where no borax was applied, deficiencies of B were very prevalent during the very dry summer months of both 1948 and 1949 as illustrated by the following summary of the 1948 data:

Borax Applied in 1946 (Pounds per Acre)	Boron Deficiency Fall of 1948
0	75%
5	18%
10	10%
20	4%
40	4%

In the tests of fourteen alfalfa varieties seeded in 1947, a French strain has been superior in recovery after mowing and yield. It is too early, however, to draw any conclusions because wilt has had no apparent effects on the stands.

Title: The Maintenance and Improvement of Pastures

Leaders: B. A. Brown and R. I. Munsell

No report on this project was made in 1948.

The Effects of Fertilizer Treatments on the Soil, the Flora, and the Production as Measured by Grazing: The average results of 1948 and 1949 (both very dry summers) show that the two plots with 30 pounds N per acre each spring and the one with poultry manure at 2

tons annually, yielded practically the same and about 10 per cent more than the optimum minerals (no N) pasture. After twenty-five years, there is still no evidence that potash has affected grazing yields, although there has been somewhat more native white clover on the plots receiving that fertilizer.

During the past two years, plot 8S, with no P added since 1924, was 46 per cent more productive than the unfertilized check.

The Adaptability of Varieties and Species of Grasses and Clovers for Pastures: In the Ladino clover management experiment, 1949 was the tenth and probably the last season. The detailed data will be published in a bulletin. Mimeographed summaries have been widely distributed in this region and copies are available on request.

The outstanding feature of this experiment is that mowing 2 inches above the ground resulted in much more Ladino clover than leaving a 4 inch stubble. The closer mowing also produced about 10 per cent higher yields of dry matter.

Causes of Fluctuations in the Prevalence of White Clover: After several years of work, it is apparent that it will be difficult to control the prevalence of native white clover by changing the P:K balance in the soil. It is clear, however, that abnormally high annual applications of P (about 300 pounds of P_2O_5 per acre) favor the spread of Kentucky bluegrass much more than the clover even when potash is also maintained at a high level (about 300 pounds K_2O per acre annually). In the Ladino clover management experiment where in the tenth season, some plots had 70 per cent stands of clover, the annual applications of P_2O_5 and K_2O have been 70 and 150 pounds per acre respectively.

MAINE AGRICULTURAL EXPERIMENT STATION

Title: Evaluation of Forage Plants, Clones, Lines, Varieties and Hybrids Developed by Plant Breeding

Leaders: C. H. Moran, W. C. Libby

An observational nursery for forage crops was established in the spring of 1949 on the University Farm at Stillwater. Selections were planted in duplicate rod-rows. Species planted included timothy, smooth bromegrass, orchard grass, reed canary, tall oat, perennial ryegrass, red clover, alsike clover, Ladino clover, alfalfa, birdsfoot and big trefoil. Notes will be taken on winter hardiness, total yield and time of production, rate of recovery after clipping, disease and insect resistance.

Title: Management Practices as they Affect the Productivity and Persistence of Ladino Clover-Grass Associations

Leaders: C. H. Moran, W. C. Libby, H. Dickey

Management studies are being conducted to compare the effects of deferred and rotational grazing on the productivity and persistence of Ladino clover-grass mixtures. Quadruplicate seedings of three mixtures (1948 Annual Report, page 46) were made in the spring of 1948.

Six of the paddocks were grazed rotationally with heifers throughout the season. A crop of silage was removed from the other six and the aftermath grazed rotationally. It was necessary to stop grazing on all paddocks on September 1 because of lack of sufficient forage due to the low soil moisture levels. Analysis of the grazing and clipping data has not been completed.

MARYLAND AGRICULTURAL EXPERIMENT STATION

Title: Orchard Grass and Bromegrass for Forage with Legumes

Leader: T. S. Ronningen

Second harvest year clipping yields based on the difference between grazed and adjacent ungrazed caged areas showed a slight decrease in production of orchard grass and associated legumes from last year. The beef animals which were used to graze the three paddocks consumed 6400 pounds of dry matter per acre in 1948 and 6200 pounds in 1949 according to the clipping results. The bromegrass paddocks provided 6500 pounds in 1948 and 5800 pounds in 1949. The alfalfa and red clover which were included in the original seeding mixture contributed very little to 1949 yields. The bromegrass in the three paddocks in which it was originally seeded had virtually disappeared also by the end of 1949. Although the growth in these paddocks consisted of Ladino clover almost entirely, no cases of bloat were noted.

Title: Red Clover Breeding

Leader: C. H. Liden

Additional red clover strains have been collected and all strains were tested for resistance to southern anthracnose. All tests were made on seedling plants which were four to five weeks of age. Approximately 12 to 51 per cent of the seedlings did not show symptoms of the disease. From the plants of 18 strains showing seedling resistance, 150 vigorous seedlings of each strain were space-planted in the field in the spring of 1949. Throughout the late spring and summer, the weak or diseased plants in the nursery were removed. Considerable virus infection was

observed, and the infected plants were destroyed as soon as the infection was noted. Only a few plants remaining showed natural anthracnose infection. After removal of diseased and weak plants, about 100 remained of each strain and 10 to 14 superior plants were given plant numbers and used for controlled crosses. Intra-strain crosses were made between the 10 to 14 selected plants. Approximately 5 to 35 seeds were obtained per head. A hive of bees was located in the nursery to increase natural inter-strain crossing. Seed from the controlled pollinations and the natural inter-strain crosses is being used during the winter of 1949-1950 in further tests for anthracnose resistance. Also, some of the same seed from each maternal line is being used in testing the material for resistance to Sclerotinia trifoliorum and Fusarium spp.

Title: Red Clover Management to Maintain Stands

Leaders: A. O. Kuhn and R. J. Allen, Jr.

This experiment, involving sixteen variations in management of stands following combining of small grain (1948 Annual Report, page 47), is being repeated for 1949-1950 at four locations in the state, with four replicates at each location.

Monthly stand counts are being made on marked areas to determine when stand losses take place. These counts indicate that when straw or clipped growth is left on the plots, the weaker plants are rapidly killed out, leaving a low stand count, but a relatively high percentage of large plants. This is in contrast to high stand count and small plants in the plots which were cut three times during the season. Yields from the 1948-1949 plots indicate that the best treatment is between these extremes.

Highest yield was obtained from the plots which were clipped and the stubble and weed growth removed shortly after combining, and then clipped and the growth removed again early in September.

Fusarium spp. have been present in all plots and in all farm fields checked, but do not appear to have much effect on stand or yields if growing conditions are favorable. Eighty per cent of the plants in one field were infected to various degrees in March, yet produced a good hay crop and a fair seed crop. However, Fusarium spp. are believed to be an important factor in the reduction of stands after the first hay crop cutting.

Ecological competition from weeds, especially common ragweed, is believed to be an important factor in reduction of stands during the seedling year. Plots which were clipped early were free from weeds and gave good growth of clover, while adjacent unclipped plots were weedy and the clover plants were few and small. At two locations which were quite free of weeds, fair stands were maintained with no clipping.

The disease "Black Patch" was severe at one location, but was effectively checked by timely clipping.

Root samples taken in December are being analyzed for carbohydrates and nitrogen in a study of root reserves as they may be affected by the various treatments.

Observations have indicated that some stand losses may be due to the fact that the plants are weakened by low soil fertility levels. A simple experiment, involving five combinations of P_2O_5, K_2O and a minor element mixture, has been set up at four locations in order to make a preliminary study of this phase of the problem.

Title: Alfalfa Variety Tests

Leader: T. S. Ronningen

First harvest year results were obtained from a second series of alfalfa varieties seeded as pure stands at four locations in Maryland. Varietal differences were small. Yields for the second harvest year were obtained from two of the locations reported in the 1948 Annual Report, page 47. Atlantic and Buffalo were generally superior. Argentine and Grimm were significantly lower yielding at several locations.

Title: Pasture Renovation Studies

Leaders: T. S. Ronningen and A. O. Kuhn

Renovation studies to compare eight seeding mixtures and disking versus shallow plowing for seedbed preparation as well as fall versus spring establishment have been continued.

The 1949 comparative yields from all plots prepared by disking as compared to the yields from all plots prepared by shallow plowing are listed below with the highest treatment total in each planting listed as 100.

	Disking	Plowing
1947 spring renovation	82.2	100
1948 spring renovation	94.4	100
1948 fall renovation (average of three locations)	100	90.5

Differences were slight in 1949 between yields from plots established in the spring of 1948 as compared to those established in the fall of 1948.

The addition of red clover to orchard grass, Ladino clover seeding mixtures resulted in increased first harvest year yields. Plots containing alfalfa in addition to the three forages named yielded even more.

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION

Title: Yield and Mineral Composition of Forage Crops as Influenced by Soils and Soil Treatments

Leader: Mack Drake, W. G. Colby and D. H. Sieling

This project was drawn up and submitted for approval to the Office of Experiment Stations in the fall of 1948. The project was approved as a Purnell project. Field plantings were made in spring and mid-summer of 1949.

Sub-projects have been developed as follows:

Sub-project 1: Effects of rates and time of application of phosphorus and potassium on the yield and composition of grasses and legumes.

We are primarily interested in the possibility of maintaining satisfactory stands of grasses and clovers as well as maintaining satisfactory mineral composition of the herbage by the use of commercial fertilizers at the proper time and in the proper way. The grasses studied include - timothy, orchard grass (Finnish Late), and smooth brome (northern strain). Alfalfa and Ladino clover are the legumes.

Sub-project 2: Effects of rate and depth of placement of phosphorus and dolomite on yield, longevity, and composition of alfalfa.

With the aid of a deep tillage sub-soiling machine, we have been able to place lime and phosphates in bands 1 foot apart at 8" and 12" depths in the soils. Deep placement is compared to shallow placement (3") also applied in bands.

Sub-project 3: Effects of rates and sources of phosphorus materials on yield and composition of forage crops.

A field experiment, including alfalfa, timothy (singly), and Ladino clover-smooth bromegrass, was established early in 1949 at Amherst, Massachusetts, on Merrimac fine sandy loam, to study the following:

1. Relative phosphorus availability of superphosphate (20% P_2O_5), rock phosphate, defluorinated rock phosphate, and treble superphosphate (45% P_2O_5) as measured by yield and plant composition.

2. Comparison of 1000 and 2000 pound rates of superphosphate, 667 and 1334 pounds of defluorinated rock phosphate, 446 pounds of treble superphosphate, and the combination of 500 pounds of superphosphate with 1000 pounds of rock phosphate.

3. Comparison of 2000, 3000 and 4000 pound rates of rock phosphate with 1000 and 2000 pounds of superphosphate.

4. Effects of three rates of sulfur with rock phosphate.

5. Effects of two rates of sulfur with deflorinated rock phosphate.

We think that the role of sulfur is of utmost importance in the production of crops high in protein. Legumes, for example, require more sulfur than phosphorus; thus, part of the yield response to superphosphate must be to sulfur as well as to phosphorus. It is possible that the application of a sulfur-rock phosphate mixture equal to that used in making superphosphate may be important in increasing the availability of phosphorus in rock phosphate. Sulfur oxidizing organisms may produce sulfuric acid in the soil in quantity to increase the availability of the rock phosphate.

A combination of rock phosphate and superphosphate may be more effective for some plants on certain soils than either carrier used singly.

We believe that large quantities of phosphate materials must be applied to New England soils to produce the desired quantity and quality (mineral and protein content) forage. We must determine if rock phosphate has a place in this forage crop program, for this material could be supplied with very low shipping and handling costs.

Preliminary data: Composition of crops produced in 1949.

Source of Phosphorus	Per cent Phosphorus		
	Timothy	Ladino clover	Alfalfa
1000 pounds of superphosphate	0.205	0.274	0.315
2000 pounds superphosphate	0.206	0.268	0.325
2000 pounds rock phosphate; no sulfur	0.190	0.268	0.293
2000 pounds rock phosphate; 100 lbs.Su	0.205	0.266	0.292
2000 pounds rock phosphate; 456 lbs.Su	0.251	0.297	0.288
3000 pounds rock phosphate; 100 lbs.Su	0.202	0.260	0.298
4000 pounds rock phosphate; 100 lbs.Su	0.214	0.274	0.287
500 pounds superphosphate + 1000 lbs. rock phosphate; 50 lbs. Su	0.218	0.278	0.290

The highest phosphorus content in both timothy and Ladino clover plants occurred on the plots with 2000 pounds of rock phosphate plus 456 pounds of sulfur. In contrast, alfalfa plants were highest in phosphate on the superphosphate plots. Yields and composition will be determined on forage produced on these plots.

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION

Title: The Fertility Needs of Ladino Clover

Leaders: F. S. Prince, L. T. Kardos and R. Feuer

The nutrient requirements of Ladino clover were studied in the greenhouse, using a Merrimac loamy sand soil low in P, K, and Ca. Treatments were replicated three times and three crops were harvested.

As little as 25 lbs. K_2O gave a highly significant increase in yield, and additional increases were secured up to 200 lbs. K_2O, although the yield increases for added K_2O over the 25-lb. level were not statistically significant.

Virtually no response was secured from applications of P_2O_5.

The unlimed treatment gave the poorest growth, although increasing the lime from one to two tons per acre did not result in a significant increase in yield.

A shotgun application of minor elements in Es-min-el, which carried Cu, Mn, Zn, B and Fe showed a slight increase in yield although not a statistically significant one. Studies are now under way to determine which of the minor nutrients influenced the yield of Ladino clover.

Title: The Influence of Pasture Irrigation Under New Hampshire Conditions

Leaders: F. S. Prince, P. T. Blood, L. T. Kardos, K. S. Morrow, H. A. Keener, B. Rines

This study was initiated at the New Hampshire Station during the 1949 season. The season was characterized by being very dry from the first of June to mid-August.

Irrigation with a sprinkler system was started on July 17. Four inches of water were applied, approximating one inch at weekly intervals until sufficient rainfall appeared to make further irrigation unnecessary.

The areas under study had been fertilized in May with 500 lbs. of 0-14-14 fertilizer per acre. Two different seedings were represented in the area chosen, one four-year old stand of timothy and Ladino clover and one area in its second year which had been seeded to timothy, red clover and Ladino clover. Part of the land was fertilized when irrigation started with 500 lbs. of 7-7-7 fertilizer per acre, so that it was possible to secure yields on land which was irrigated and fertilized, or with irrigation alone as well as from land not irrigated but fertilized or unfertilized.

Yield data are presented below:

Reservoir Field (Four-year old stand)

Treatment	Yield Dry Matter per A
Fertilized and Irrigated (2 cuts)	3132 lbs.
Unfertilized and Irrigated (2 cuts)	2888 "
Fertilized and Not Irrigated (1 cut)	1810 "
Unfertilized and Not Irrigated (1 cut)	990 "
Fertilized and Irrigated Lightly (1 cut)	1507 "
Unfertilized and Irrigated Lightly (1 cut)	1062 "
Pond Field (Second-Year Stand)	
Fertilized and Irrigated (2 cuts)	3510 "
Unfertilized and Irrigated (2 cuts)	3586 "
Fertilized and Not Irrigated (1 cut)	1687 "
Unfertilized and Not Irrigated (1 cut)	1204 "

By mid-August there was a good harvest on the irrigated areas, whether fertilized or not, and the first harvest was taken then. In the table, the two harvests on the irrigated areas are presented, along with the yields of one harvest, on the non-irrigated areas. The second harvest on the irrigated areas was taken at the same time as the harvest on the non-irrigated areas. It will be noted that the irrigated areas heavily outyielded the non-irrigated areas, but that in regard to the fertilizer, the response was greater on the non-irrigated than on the irrigated areas.

Another factor noted was that the Ladino clover in reservoir field appeared to survive better on the irrigated areas.

	Percentage of Forage, 2nd Harvest	
	Grass	Clover
Fertilized and Irrigated	87.6	12.4
Unfertilized and Irrigated	80.6	19.4
Fertilized and Not Irrigated	94.9	5.1
Unfertilized and Not Irrigated	93.4	6.6

These botanical separations were made on the second cutting from reservoir field, at which time all the material from each of the 16 foot square cages was separated. Whether these differences in percentage of Ladino clover will persist into the 1950 season, we do not know.

Title: Maximum use of Roughage in Feeding Dairy Cattle

Leaders: H. A. Keener and K. S. Morrow

Studies are being made on the relative value of forage preserved by various methods. Last year the study included a comparison of field curing, mow curing without heat, and ensiling without preservative. On a comparable moisture basis, the silage ranked first in both protein and energy, the mow-cured hay second, and the field-cured hay third. It was found, however, that when each roughage was fed as the sole ration, both the protein and the energy of the silage were less digestible than in either hay. On the other hand when these roughages were fed to dairy heifers along with a small amount of grain, those heifers which received the silage gained approximately 50% more in weight than those which received either hay. This was in spite of the fact that the silage animals had a considerably lower nutrient intake. The lowered digestibility of the silage would appear to have been due either to a shortage of carbohydrates for the rumen flora or to some other situation in the rumen.

This year the study includes a comparison of field curing, mow curing, ensiling by the wilting method, and ensiling with 80 pounds of molasses per ton. Both digestion and utilization studies and feeding experiments are being carried out with dairy heifers to determine the relative values of these roughages. In addition studies are being made to determine those combinations of hay, grass silage and corn silage which will give the greatest nutrient consumption and the greatest growth rate with dairy heifers, which receive no concentrates.

Title: Analysis of Forage Samples

Leaders: G. P. Percival, M. E. Loughlin, T. G. Phillips and D. Josselyn

In order to determine the effect of widely-differing methods of preservation on the content of carotene, carbohydrates, nitrogen compounds and possibly lignin, Ladino clover, alsike, and red clovers and timothy were sampled. These single species' samples were carried through all processes and the effect on composition for each method of preservation was studied. There was no significant change in protein content in the 1948 or 1949 samples. Basing the losses in carotene content on the amount present at cutting, Ladino clover had lost the least, and red clover the most when the samples were taken out of the silo at the end of about 6 months. The alsike clover and timothy had lost about equal amounts which was about half-way between the above two. With both mow dry and field dry samples the losses, calculated on the above basis, were about the same for each species for each method. The general average of the losses for all species for both years after about 6 months' storage were silage 54%, mow cured 86%, field cured 90%.

Losses in carotene content based on the amount present in the various samples when they were placed in the silo and in both mows showed that during the process of ensiling the red clover had lost a much greater amount than the other species and the Ladino clover the least amount. During the process of mow curing (the samples taken out when the hay was considered dry) the Ladino clover had lost by far the greater amount, while the losses on the other three species were about equal. In the case of the field dry method, the losses were about the same for all species.

NEW JERSEY AGRICULTURAL EXPERIMENT STATION

Title: Belle Ellen Pasture Experiment

Leaders: C. B. Bender and Claude Eby

Object: To obtain productive values of tall growing grasses and legumes in a pasture sward.

Procedure: The 1949 grazing season was characterized by early spring grazing, the cows going on pasture April 13th, a six weeks drouth during the latter part of May and all of June, little grazing in July and a fair amount in August, September and October. A summary

of the 1949 data follows:

Belle Ellen Pasture No.	Type Forage	1000 pound cow days per acre
1-2	Orchard - Ladino	252
3	Brome - Ladino	238
4	Bluegrass-White Clover	189
6	Orchard - White Clover	241
7	Sudan grass	180
8-9	Orchard - Ladino	259
13	Bluegrass-Ladino	149
14	Bluegrass-Ladino	209
15	Orchard grass	156

Title: Studies of Reed Canary Grass for Pasture and Hay

Leaders: M. A. Sprague, Claude Eby and C. B. Bender

Object: In studying the value of reed canary grass as a hay and pasture plant, protein analyses were made of 50 stem samples cut at various stages of growth.

Stage of Growth	Date	% Protein	% Dry Weight
6"	4/23/48	24.50	20.6
12"	5/17/48	17.56	16.9
18"	6/2/48	13.35	22.6
24"	6/2/48	13.45	22.2
48"	6/12/48	9.00	29.1
64"	6/25/48	6.61	55.8

These samples were taken from a 5 year old stand of Ladino clover and reed canary grass. Herbage analysis showed a 97 per cent coverage, with the herbage made up of 50 per cent reed canary grass, 40 per cent Ladino clover, 6 per cent orchard grass and 1 per cent weeds. Fertilization was on the basis of 500 pounds of a 5-10-10 mixture applied broadcast each year in November. Soils test indicated a high available magnesium, a medium to high phosphorus level, high in potash and low in nitrogen with a pH of 6.4. The soil of the area is a Dutchess loam and stony loam, not adapted for alfalfa or corn. Yields over the 5 year period have averaged 12 tons green weight per acre.

Title: The Utilization of Potash and Nitrogen by Ladino Clover Under Grazing Conditions

Leader: M. A. Sprague

The experiment as described on page 53, Annual Report for 1948, was carried on a second season. Percentages of clover in October, 1949 were determined in terms of per cent ground covered with the aid of grid quadrat. Already the effects of high nitrogen applications were beginning to express themselves in terms of lower clover populations. During the first season, 1949, no differences in clover populations were evident between the levels of potash applied or between times of application.

Title: The Utilization of Pastures in the Production of Pork

Leaders: M. A. Sprague and George W. Van der Noot

Separate lots of pigs, averaging 37 pounds each and carried during the summer season on alfalfa, Ladino clover and Ladino-grass pastures, returned an average daily gain of 1.39, 1.34, and 1.30 pounds. A 14 per cent feed was self fed while on pasture and feed consumed per pound of gain was 3.34, 3.25, and 3.38 pounds respectively. Ladino clover again demonstrated its superiority as a pasture plant by producing nearly as rapid gains as alfalfa with less supplementary feed. Likewise, its ability to persist under grazing conditions favors Ladino clover when compared with alfalfa. Grass-clover pastures have consistently given poorer results with hogs than pure stands of a legume.

Larger numbers of pigs at the Bordentown Prison Farm grazed Ladino clover and alfalfa with separate lots on each pasture which were self fed a 14 per cent ration and corn plus a protein supplement. Pigs fed corn plus a supplement on pasture gained 0.93 pound on Ladino clover and 1.01 pounds per day on alfalfa. Those fed a 14 per cent ration gained 1.17 pounds on Ladino clover and 1.25 pounds per day on alfalfa. Similar lots fed in a dry lot gained 1.00 pound per day on corn and supplement and 0.76 pound per day on the 14 per cent ration.

Title: All Roughage and Pasture Feeding Experiments with Dairy Cattle

Leaders: M. A. Sprague and C. B. Bender

A study is underway to determine the maximum use which can be made of the more economical feeds, hay, silage and pasture in the production of milk (1947 Annual Report, page 52). The results of the 1949 grazing season bore out in many respects those received during the previous two years. Considering the three year average, bromegrass and Ladino clover produced 5844 pounds per acre of dry forage, while orchard grass and Ladino clover produced 6007 pounds per acre. Bluegrass and white clover treated similarly produced only 4130 pounds and reed canary grass-Ladino clover 4683 pounds. These determinations are in terms of consumed forage per acre. The reed canary grass-Ladino clover yielded greater tonnage in total than indicated but considerable difficulty was experienced in getting the dairy animals to consume the reed canary grass.

Title: Small grains for Fall and Spring Pasture

Leader: M. A. Sprague

Trials undertaken to determine the use of small grains for pasture (1947 Annual Report, page 54) were continued to determine the response of rye, wheat, and oats to fall and spring grazing practices. Data were collected on forage yields and subsequent yields of grain and straw.

A two year summary indicates that rye yielded almost 3000 pounds of forage when grazed fall and spring, wheat grazed 1500 pounds, and oats 1000 pounds. A single spring grazing of these same grains yielded 2600, 1400, and 900 pounds respectively. Approximately 60 per cent of the forage produced by oats was produced in the fall of the year. The reverse was true with rye and wheat which produced 60 per cent of their forage in the spring of the year.

A two year summary of grain harvest indicated that in the case of each grain a single fall grazing increased the subsequent yield of grain over the areas not fall grazed by approximately 10 per cent. A single spring grazing reduced the yield of grain over the areas not fall grazed by approximately 22 per cent. Areas which were both fall and spring grazed yielded almost as much grain per acre as the areas which had not been grazed in the fall or in the spring. Straw yields and test weights offered similar comparisons.

Counts were made of productive tillers and no differences were apparent between plots which had been grazed and those not grazed. Converting the yields of grain and of forage to total digestible nutrients by means of Morrison's standards, it is observed that the total yield of T.D.N. where fall grazed was increased 46 per cent; where spring grazed 57 per cent; and where fall and spring grazed 78 per cent above the yield of T.D.N. from plots not grazed.

Title: Winterkilling Studies with Ladino Clover

Leaders: Glen M. Wood and M. A. Sprague

This study was undertaken first in the fall of 1948 at which time two clones of Ladino clover which had been multiplied for test material were submitted to several clipping treatments in order to establish levels of carbohydrate reserves within the plants. Clippings were made on September 1, October 1, and November 1. Stolon samples were drawn January 1, February 1, March 1 and analyzed for carbohydrates with a breakdown of sugars, nitrogen and total polysaccarides. Histological observations were made and these compared with findings of carbohydrates in the cold hardy and a non-hardy clone.

Freezing at controlled temperatures followed by subsequent recovery under greenhouse conditions has served to relate fall clipping treatments to cold hardiness.

Title: The Utilization of Pastures in the Production of Beef

Leaders: M. A. Sprague and Paul Grinde

This is a project set up in 1947 (Annual Report 1947, page 55). In December, 1948 19 calves were placed on winter feed consisting of all of the grass silage they would eat plus limited rations of hay and grain. They were maintained on this ration until April 22 at which time all of the animals plus 1, making a total of 20, were placed on 5 rotation pastures consisting of 13.5 acres of Ladino clover-bromegrass and 9 acres of Ladino clover-orchard grass.

On April 22 these 20 animals were placed on 22 acres of improved pasture without supplement to October 25. During this time, the animals gained 1.4 pounds per day on grass alone. The 226 pounds of beef produced per acre plus 4 tons of silage per acre on May 28 is considered an excellent return on this type of land. No supplementary pasture of sudan grass was required even though 1949 was one of the driest seasons on record for New Brunswick.

Title: Supplemental Irrigation on Pasture

Leaders: George R. Blake, C. S. Garrison, E. R. Purvis, M. A. Sprague and N. A. Willets

This study was begun in 1947 to determine the advisability of using supplemental irrigation on improved pastures and to determine in part which of three fertilizers 0-10-10, 5-10-10 or 20-10-10 would be most advisable to use under irrigation. The study continued through the summer of 1949 and was completed in the fall. The major part of the experiment was conducted on an 8 acre field in Burlington County (1947 Annual Report, page 53).

Several conclusions were drawn from this study.

Irrigation costs totaled $7.90 per acre inch or $26 per acre per year for the combined years 1947, 1948 and 1949. This was an average of $15 per acre per year more than the actual market value of the herbage produced. In the drouth year 1949 there was an economic return from irrigation. It was concluded that increased experience and efficiency might reduce costs to permit an economic return. Much would depend on the size of the individual farm operation, and on efficient use of labor. It is possible too that green feed during a drouth may be worth more than the conventional market price if milk production can be sustained. The data indicate that irrigation should probably be considered as an emergency rather than as a routine measure for pasture production.

No difference in protein content of irrigated vs. non irrigated pasture was detected in the 1949 drouth year.

By the end of the experiment nearly all of the alfalfa had disappeared from the pasture and there were slight differences in alfalfa populations in favor of the non-irrigated area. Ladino clover percentages remained nearly constant whereas grass and weed populations increased under irrigation. The yearly averages indicate that plots which received up to 40 pounds of nitrogen yielded considerably more dry matter than plots which received none. One hundred sixty pounds of potash gave no appreciable increase in yields over 80 pounds under normal rainfall except some increase in yield where irrigation supplemented high potash applications.

Title: Rate of Fertilization Study with Pastures in New Jersey

Leader: E. R. Purvis

The attached table summarizes a 3-year pasture fertilization study conducted at 2 locations in New Jersey. The pasture stand in the Monmouth County test consisted of a mixture of Ladino clover and orchard grass, while that in Morris County consisted of Ladino clover, timothy and bluegrass.

Annual fertilizer applications, at the rates indicated, were made after the first harvests. The plots were harvested with a sickle-bar power mower and were cut 4 times annually except where indicated.

The decrease in yield from the plots receiving no fertilizer was striking while all 3 rates of fertilization maintained fairly constant increases. Soil test data show that the 500 pounds per acre maintained the original fertility level of the soil while the higher rates of application increased the fertility level.

Pasture Yields in Pounds Dry Weight Per Acre
Treatment in lbs. per acre of 5-10-10 Fertilizer

Year	Monmouth County Sassafras sandy loam				Morris County Washington loam*			
	No fertilizer lbs.	500 lbs.	1000 lbs.	2000 lbs.	No fertilizer lbs.	500 lbs.	1000 lbs.	2000 lbs.
1947	5725	6614	6902	7800	4560	5174	5394	6057
1948	4902	6292	6635	6991	3041	3663	4358	4227
1949	4008	6290	6391	7543	1399	2204	3097	4180

* 1948 and 1949 data for 1st and 2nd clipping only.

Title: All Roughage and Pasture Feeding Experiments with Dairy Cattle

Leaders: C. B. Bender and M. A. Sprague

A study is underway to determine the milk producing potentials of the more economical feedstuffs, pasture hay and silage, in the production of milk. (Annual Reports 1946, page 53, 1947 page 52, and 1948 page 52).

A preliminary analysis of the data collected on this project indicates the following:

1. Dairy cows fed liberal amounts of high quality roughages alone can produce 83% of their potential production on heavy grain feeding.

2. The results of the pasture phase of this project show that dairy cows weighing 1200 pounds can produce 25 pounds of 4% milk per day on good pasture and hay as the only source of feed.

3. Improved hay type grass legume pastures maintained at a high level of fertility and under good grazing management maintained .94 cows per acre for the pasture season.

CORNELL UNIVERSITY (NEW YORK) AGRICULTURAL EXPERIMENT STATION

Title: Breeding and Cytogenetic Investigations with the Forage Plants of New York

Leaders: R. P. Murphy, S. S. Atwood, C. N. Hittle and C. C. Lowe

The material for this report will be presented here in the same order as in the previous reports. (1948 Annual Report, pages 55 to 58).

Bromegrass: The one- and two-year inbred progenies that were established in replicated 10-plant spaced rows in the summer of 1948 made only fair growth in 1949. None were as vigorous as the Fischer check variety. The outstanding one-year inbred lines that were isolated from the more extensive planting made in 1946 were planted in isolated seed-production plots in 1948. (See page 55 in the 1948 Annual Report for listing of families). These isolation plots made excellent growth in 1949 and all produced high yields of seed except the I_1 family of 217-56 in which many of the clones were found to be rather poor seed producers even under conditions of open-pollination. These synthetics and the progeny of each of the component plants will be seeded in 1950 in replicated trials in order to determine their performance. The clones that were selected from the original I_1 nursery and that were established in a replicated spaced plant nursery in 1948 for clonal evaluation and polycross seed-production, made very poor growth in 1949 because of low soil fertility and dry weather.

This planting was heavily fertilized, and it is hoped that seed will be produced in 1950. On the average, the clones from the Fischer check variety were significantly more vigorous than those from the I_1 progenies. However, good clones were found in both groups. A report on the use of I_1 families in the breeding of bromegrass was given at the 1949 meetings of the American Society of Agronomy and will be published later. The polycross progeny plot test that was seeded in 1948 was harvested for the first hay cut only in 1949. The aftermath yield was not harvested because of extreme drouth conditions. The stands are excellent. The study of the variation in open-pollinated seed set among this group of clones has been part of a thesis for Mr. Lowe. The variation seems to be primarily genetical and not environmental. Preliminary cytological investigations did not show important results, and no further work along this line has been done this year.

Good establishment, growth and seed production were obtained from each of the four isolated plots of selected clones from the 1946 polycross nursery for the development of synthetic varieties. These will be tested in the same manner as was outlined above for the synthetics developed from one-year-inbred families.

The number of clones that were finally selected for polycross progeny testing from the 1947 nursery of New York clones and the 1947 nursery of Pasture Laboratory clones were 54 and 26 respectively. These polycross progeny tests were established in 1949, and only fair stands were obtained because of the dry year. In addition a replicated plot test of the polycross seed produced in 1947 and in 1948 for each of 12 clones from the 1946 polycross nursery was established to determine the variation in performance of the progeny produced in different years.

The material planted in 1948 for the study designed to observe the variation in the polycross progeny from ten heads each, selected from different replications in the 1946 polycross nursery, was studied intensively in 1949 and will be continued for one more year. This is part of a thesis for Mr. Hittle.

Timothy: The best plants from the 1946 I_1 nursery and the 1946 polycross seed production nursery are being maintained vegetatively in a 'museum' nursery for future use and the original plantings have been discarded. Polycross seed was harvested from 56 out of 240 clones originally planted in the 1948 polycross seed production nursery, and it is planned to establish replicated plot trials of these progeny tests in 1950.

Reed Canary Grass: In 1948 a polycross seed production nursery, which contained 150 clones selected from the 1946 source nursery at Tully, New York, was established, and polycross seed from 85 clones was harvested in 1949. It is planned to plant the seed in a replicated plot trial in 1950. A number of plants were selected from the 1947 source nursery at Tully, New York and are being maintained vegetatively in a 'museum' nursery for future use.

Tall Oat Grass: The best plants from the 1946 I_1 nursery and from a 1945 source nursery are being maintained vegetatively in a museum nursery for future use and the original plantings have been discarded. A polycross seed production nursery was established in 1949 with ten replications of spaced plants of 240 clones selected from the 1946 and 1947 source nurseries at Tully, New York. Seed of the better clones will be harvested in 1950 for use in progeny testing.

Orchard Grass: From the 1947 polycross seed production nursery, which contained 284 clones selected by the Pasture Laboratory, 108 clones were selected for polycross progeny testing by the Agronomy Department of The Pennsylvania State College and by New York. A similar planting in a replicated plot trial was made at each location. However, because of the very dry year the stand establishment at Ithaca was poor and it is doubtful if this planting will be of value. Insofar as seed is available, this test will be replanted in 1950 if the 1949 planting is discarded. A new polycross seed production nursery was established in 1949 with good establishment. The nursery contains 160 clones which came from the Minnesota station, the Pasture Laboratory and New York.

Meadow and Tall Fescue: The 1946 and 1947 source nurseries of these species at Tully, New York have been discarded and no further breeding work is planned at the present time. No selected plants are being maintained.

Source Nurseries - Tully, New York: The extensive spaced-plant source nurseries of timothy, reed canary, tall oat grass, and meadow and tall fescue established in 1946 and 1947 were discarded in the fall of 1949. Excellent material for selection was present in all of those species and is the basis for the breeding program with the first three named.

Technique Study and Evaluation of Miscellaneous Materials: The material included in the technique study was outlined in the 1947 Report, page 58 and reported briefly in the 1948 Report, page 57. The better clones of the orchard grass and tall oat grass have been included in the 1949 polycross seed production nurseries for each of these species. The better clones of the red fescue are being maintained vegetatively in the 'museum' nursery and the clones of the perennial ryegrass insofar as they have survived are being maintained. The selected clones of meadow foxtail are being maintained but no progeny test of these has been made because of low seed production.

The experiment which was planted in 1947 to measure the variation in method of planting and kind of progeny test with selected clones of orchard grass, bromegrass and red fescue was continued in 1949. The planting was plowed in the fall of 1949; the data for the two growing seasons will be summarized as soon as possible and the results will be reported at that time.

The clones of Cornell 1777 and 4059 and the clones of Zigzag clover are being maintained.

The planting of the polycross seed progenies of 18 of the cooperative Ladino clover clones in comparison with imported and Oregon-certified lots was continued. All of these seemed to be of the "gigas" or Ladino type although there was some variation in some of the polycross progenies.

The alfalfa studies conducted under this project are being described in Part I of this report under the heading "Medicago sativa breeding", since this phase of the work is partially supported by U.S.D.A. funds.

Title: Strain Testing and Breeding of Forage Plants for New York State and Vicinity with Special Emphasis on Problems of Production During Periods of Midsummer Drouth.

Leaders: R. P. Murphy, S. S. Atwood, H. A. MacDonald, R. D. Ensign, C. N. Hittle and C. C. Lowe

Most of the varietal plots seeded in 1945, 1946, 1947 and 1948 which have been described in the previous Annual Reports were harvested for yield in 1949, but detailed results will not be presented here. The plots seeded in 1945 and 1946 at the Ketola field, Ithaca have been discarded, and only part of them was harvested in 1949. These plantings are on several different fields at Ithaca and at Tully, Churchville and farmers' fields in five different counties in the state. In general the results obtained in 1949 further corroborated those from previous years. These data are summarized in a mimeographed statement, P. B. 49-8, and are available to anyone interested. For a briefer report of the variety recommendations which are made by Cornell, the reader is referred to our extension publication entitled "Cornell Recommends For Field Crops".

Among the new varieties which appear promising and will be recommended when seed is available if their performance continues to be good are the following: Narragansett and Atlantic alfalfa; Kenland and Cumberland red clover; Achenbach, Elsberry, Fischer and Lincoln bromegrass; and possibly Lorain, Climax and Hopkins timothy because of their late maturity.

The results of the study of aftermath growth of bromegrass at controlled high temperatures in cooperation with the U. S. Plant, Soil and Nutrition Laboratory will be submitted for publication in the future. No further research on this phase of the project is planned at present.

The thesis study of Dr. H. R. Fortmann on the response of five varieties of bromegrass to several nitrogen fertilization and cutting treatments has been summarized by him and presented in a thesis filed at Cornell University. Additional data were obtained in 1949 and all of the results were presented in a paper at the 1949 meetings of the American Society of Agronomy and will be published soon. The plots used in this study have been plowed and further work is not planned at the present time.

Title: Some Factors Affecting the Seedling Establishment of Forage Legumes

Leaders: H. A. MacDonald and W. A. Williams

Object: Failure of the legume component of forage seedlings is a pressing problem to the farmers of this region. There is evidence that the stand obtained in legume seedings is unsatisfactory more often than with any other major crop. Hence, the purpose of this investigation is to study some of the more important factors influencing the emergence and subsequent growth up to the first harvest.

Progress: Experiments have been initiated to study the effect of the following factors:

(1) Seedbed preparation
  (a) Degree of compaction
  (b) Crusting
  (c) Mulching
  (d) Tillage implements
(2) Methods of seeding
(3) Fertilizer placement
(4) Date of seeding
(5) Tillage methods in pasture renovation
(6) Companion crop competition
(7) Population density and winter killing

Evidence to date indicates that soil moisture during emergence and early growth, and fertility level are of prime importance. Reduction of competition from original sod appears to be a major factor in the renovation of hill lands that cannot be plowed.

Title: Studies of Birdsfoot trefoil as a forage legume in New York

Leader: H. A. MacDonald

Progress: Further studies concerned with the culture, improvement and use of birdsfoot trefoil were conducted during 1949. Under the prevailing dry summer conditions this legume made superior production in situations where other less drought-resistant legumes made little or no growth. This legume now appears to have a much wider adaptation and use than at first appreciated.

Special attention was devoted to the problem of seedling establishment. Spring seedings made good growth. Mid-summer seedings were largely failures except where moisture was adequate or applied. Nitrogen fertilization aided establishment except on the most productive soils. Inadequate inoculation and lack of nitrogen fixation were found to contribute to many seeding failures. Improvement was obtained where (1) an increased amount of inoculating culture was used, (2) mineral fertilization and lime were adequate, (3) soil not too low in organic matter and (4) additional inoculant was applied to weak seedling stands. Inherent seedling vigor was found to be closely related to success in establishment.

All sources and varieties of birdsfoot trefoil (Lotus corniculatus L.) have proved to be quite winter hardy. A number of selections are proving to be superior to the Empire variety in yield but are several days earlier in reaching maturity. One variety, for use as hay and rotation pasture, is now being increased for release in the fall of 1950.

Investigations relative to seed setting and seed production are being continued. In many cases the flower buds have been found to abscise at an early stage of development. This is most common in dry locations and in dry years. Studies now in progress indicate that this is due, in part, to a nutrient unbalance. Boron application has been of value in some situations but has not given complete control.

Summer killing of birdsfoot trefoil has been found to be due in part to a Rhizoctonia root and crown disease. The varieties making rapid recovery following harvest have been less affected than the slower growing sorts.

Title: The effect of stage of growth upon the (1) yield as hay and pasture, (2) longevity of stand, and (3) nutritional value of the principal forage grasses and legumes.

Leader: H. A. MacDonald

Progress: The extensive data now accumulated from this investigation are now being analyzed in preparation for publication. Further work concerned with the concentration of minor elements in forage is also under way. Differences between varieties, in any of the characters under study, have been found to be smaller than those between species except where disease or some other factor was involved.

The results of the most recent studies are not sufficiently advanced for reporting at this time.

Title: The Effect of Seeding Rates, Fertilizer Application, and Management in Forage Mixtures on the Survival and Productivity of alfalfa under Various New York Environments.

Leaders: W. K. Kennedy, R. Bradfield, and H. Fribourg

Progress: Alfalfa was seeded alone and in combination with red clover and/or timothy at three locations. The rates of seeding of the three species were varied and Ladino clover was included in three treatments. The number of plants of each species per unit area will be recorded at regular intervals. The effect of removing three hay crops compared to two hay crops on the productivity and maintenance of stand will be studied in 1950 and subsequent years.

Title: The Effect of Feeding Dairy Cows Certain Fungicides Used To Prevent Mold Growth in Hay on the Production and Quality of Milk

Leaders: Agronomy - W. K. Kennedy and R. Bradfield
Animal Husbandry - J. Thomas Reid, George Trimberger, and K. S. Turk

Progress: Two fungicides which have prevented mold growth on hay containing 30 to 35 per cent moisture will be fed to dairy cows in order to determine their toxicity and effect on the quality of the milk. The chemicals will be mixed with rehydrated hay and grain which will be stored for 6 to 8 weeks before feeding. Similar amounts of the chemical will be fed directly to other cows. The milk will be analyzed to determine if the chemicals are secreted into the milk.

Title: The Relationship of Milk Production to Herbage Characteristics from Permanent and Rotation Pasture Mixtures

Leaders: Animal Husbandry: J. Thomas Reid, George Trimberger, and K. S. Turk
Agronomy: W. K. Kennedy, H. A. MacDonald, and R. Bradfield

Object: To evaluate permanent and rotation pasture mixtures. Data on the following will be obtained: (a) milk production per acre and per cow, (b) seasonal carrying capacity, (c) herbage consumption per cow, (d) herbage production per acre, (e) chemical composition of herbage and its relationship to digestibility, (f) botanical composition, (g) cost of production.

Progress: Six lots of each of three mixtures were alternately grazed in 1949. The mixtures were (1) permanent pasture, (2) orchard grass and Ladino clover, and (3) brome grass, Ladino clover, and alfalfa. (The latter two mixtures are to be plowed and resown in oats every four years). The yield of milk and dry matter per acre was highest for the bromegrass, Ladino clover and alfalfa pasture and lowest for the permanent pasture. The yield of the Ladino clover and orchard grass pasture was lower than the pasture containing alfalfa but since all of the seeded pastures were only one year old this probably favored the alfalfa pastures.

The correlation coefficient of milk production and amount of pasture consumed was 0.84 or higher for each pasture mixture, and the regression coefficients indicated that the amount of milk produced per pound of pasture herbage (dry matter basis) consumed was the same for all mixtures.

Title: Factors Which Influence the Longevity, Seasonal Growth and Productivity of Ladino Clover

Leaders: W. K. Kennedy, E. M. Kroth and R. E. Sigafus

Progress: The effect of kind, rate, and date of fertilization on the yield and botanical composition of a grass-Ladino clover association is being studied at two locations. The total seasonal yield has been highest for plots receiving annual applications of 50-50-50. The first cutting from this treatment was especially heavy with little increase over the check for subsequent cuttings; however, the percentage of clover was high in the aftermath cuts. Plots receiving fall applications of 0-50-50 yielded well but spring applications resulted in little increase in yield. The data indicate that it is necessary to apply the phosphorus the previous fall if maximum benefits are to be obtained. Both phosphorus and potassium were needed to secure a yield response to fertilization.

The effect of time and intensity of cutting, and fertilization practices on the food reserves and winter hardiness of Ladino clover is being studied. Specific clovers as well as plots seeded with certified Ladino clover received different management treatments during 1949 and preceding years. During the fall, winter, and spring of 1949-50, stolon and root samples of Ladino clover will be taken for chemical analysis. The effects of previous treatment on winter killing and injury, and spring growth, will be recorded.

Title: Clover Root Borer Investigations

Leaders: George G. Gyrisco and D. S. Marshall

In several experiments conducted in New York State in 1949 against the clover root borer, Hylastinus obscurus, "Octalox", benzene hexachloride and "Octalene" in that order appeared to be the most effective materials tested. In single trials Octalox and Octalene at the rate of 2 pounds of actual toxicant per acre appeared very promising for clover root borer control. These two materials controlled better than 90 per cent of the borers in the treated plots.

In two concentration experiments to determine the minimum effective dosage of parathion and benzene hexachloride, it was found that at least 0.75 pounds of parathion or gamma isomer of benzene hexachloride is needed for practical control of the clover root borer.

Since many workers in the past have shown that the food habits of one species of insect may often affect its susceptibility to the same insecticide, twenty varieties of red clover were treated with the same insecticide, lindane, with appropriate untreated checks being left in each case. The treated blocks served to indicate whether varietal differences affected clover root borer susceptibility to lindane while the untreated blocks indicated whether

any varieties showed resistance to clover root borer attack. In no case did the variation in food affect the susceptibility of the borer to lindane. Only 4 roots or 0.5 per cent were infested in the treated plots of the 800 roots of the 20 varieties that were examined. While no varietal immunity occurred in the untreated blocks, a few varieties such as Manhardy, Otten and Emerson showed a low infestation and will warrant further investigation.

Title: Alfalfa Snout Beetle Investigations

Leaders: G. G. Gyrisco, D. S. Marshall and C. E. Palm

During 1949 in a small plot field experiment in Jefferson County using dusts of toxaphene, chlordan, parathion, benzene hexachloride, "Octalox" and "Octalene" as well as peanut shell-sodium fluosilicate bait, Octalox, Octalene and parathion were found to be the most effective materials tested. Octalene and parathion are of particular interest and promise for use on forage crops since all the toxic residue of these materials is lost by evaporation and degradation in about 30 days.

Preliminary tests with Octalox, chlordan and Octalene as larvacides when used as surface soil treatments were very encouraging but more work is necessary under conditions of heavy infestation before these materials can be evaluated on a practical basis.

As in the past year, helicopter treatments of infestations of alfalfa snout beetles were made. Chlordan, parathion and benzene hexachloride dusts were found to be the most effective materials tested. It is believed that this method of treating infestations of snout beetle could be employed very effectively on sod land in conjunction with a baiting program which would be used on freshly plowed land. Baiting appears to be more effective on plowed land and less effective than aircraft on sod ground.

Thermal aerosol application of insecticides was used in several tests against the alfalfa snout beetle during periods of migration in deep grass areas. Oil solutions of 2-7 per cent toxaphene, benzene hexachloride and Octalox were used in the various tests. This method of beetle treatment was highly effective even during adverse conditions for treatment. However, further work with this machine using cheaper water suspensions and smaller concentrations of oil solutions of insecticides in another year are necessary before thoroughly evaluating this method of control.

Title: European Chafer Studies

Leaders: R. H. Burrage and G. G. Gyrisco

Further work in several replicated cage and field tests with chlorinated hydrocarbons and organic phosphates during 1949 indicated that chlordan, benzene hexachloride, parathion, Octalox and Octalene can all be used effectively for the control of European chafer grubs in

the soil. Several concentrations of each toxicant were used in the early tests during 1949 and all were found to be effective. Two pounds of actual toxicant per acre was the lowest dosage used for Octalox, Octalene and benzene hexachloride while 8 pounds of actual toxicant per acre was the lowest concentration of parathion and chlordan used. Lead arsenate when used at the rate of 250 pounds of insecticide per acre was also found to be effective.

Early results from further field tests, still in progress, indicated that no significant reductions in grubs occurred from treatments of DDT up to 10 pounds of actual toxicant per acre nor up to 5 pounds of chlordan. One-half pound of gamma isomer of benzene hexachloride per acre was also not satisfactory. Significant reductions of grubs were recorded from the application to the surface of the soil of as little as 1 pound of actual toxicant per acre of the following materials: parathion, Octalox, Octalene and benzene hexachloride.

Excellent kills of adult beetles during mating flights were obtained with thermal aerosols in large field experiments. One per cent benzene hexachloride, 9 per cent toxaphene, 4.5 per cent Octalox and 2.25 per cent Octalene solutions of a horticultural type oil when used as thermal aerosols gave spectacular kills of thousands of beetles during mating flights.

Dust and spray treatments of adult beetles using many of the newer chlorinated hydrocarbons and organic phosphates were found also to be highly effective.

Title: White Grub Investigations

Leaders: R. H. Burrage and G. G. Gyrisco

Brood C June beetles which make up most of the white grub infestations in New York were in flight during the spring of 1949. However, only a comparatively small number of beetles were recorded throughout the State and no serious damage was reported. Light traps were maintained at Minetto, Oswego, Lake Placid, Chazy and Wesport, New York, but only a small number of beetles was taken from June-August.

Life and seasonal history studies were initiated at Minetto and are now in progress.

Unseasonably dry weather during late May and throughout most of the summer in the Champlain Valley, St. Lawrence Valley and the Great Lakes Region was responsible for the destruction of many young white grubs. As a result, there will be little white grub injury in those regions in 1950 and a small flight of Brood C beetles is anticipated in 1952.

Since many of the new chlorinated hydrocarbons and organic phosphates have shown promise for white grub control, chlordan, parathion, Octalene, Octalox, benzene hexachloride and lead arsenate were used as soil insecticides at several levels of concentration on land upon which strawberries were later planted in order to determine the effects of these materials upon the development of strawberry plants. To date, six months after planting, the strawberry plants have exhibited no undesirable characteristics that can be attributed to the soil insecticides which were applied. Further observations will be made during the summer of 1950 on these plots, especially for any abnormal flavor in the fruit.

Title: Resistance of Alfalfa to Insects

Leaders: G. G. Gyrisco, S. S. Atwood, D. S. Marshall and R. P. Murphy

During 1949, further studies were conducted in cooperation with the Department of Plant Breeding on the resistance of 131 selected alfalfa clones to several alfalfa insects; namely, the pea aphid, the potato leafhopper and the meadow spittlebug.

In 1948, pea aphids had been successfully reared from an original single stem mother, raised on broad beans, and transferred to alfalfa for all the tests. During 1949 under similar conditions using the same pea aphid culture, the aphids could not be transplanted successfully from broad beans to alfalfa. Studies were initiated to find the cause of this strange behavior in food preference and to find ways of solving this difficulty.

RHODE ISLAND AGRICULTURAL EXPERIMENT STATION

Title: The Response of Strains and Mixtures of Forage Plants to Grazing.

Leader: Irene H. Stuckey

The severe drought during the summer of 1949 cut the yields on the pasture plots even more than the dry weather the previous summer, but caused no permanent damage as the rapid recovery following rain in the fall showed. Twice during the summer, from July 12 until July 27 and again from August 2 until September 28, the quantities of forage available were so limited that the heifers had to be removed from the plots entirely to prevent damage to the pastures. The grazing ended for the season on October 24 which is the usual time in Rhode Island.

At intervals during the summer, the plots were examined for species which had not been planted there originally. Weed species, both annual and perennial were more numerous on plots where areas of bare soil had remained exposed for any length of time either by the slow growth of the original forage plants or by removal of these plants because of disease or other factors. Plots on which a dense cover of the original species had been maintained since the original seeding in 1945 had almost no weeds. Bare ground seemed to be necessary for the establishment of daisy, dandelion, both velvet and Colonial bent grass and some of the annual weeds: ragweed, toadflax, mouse-eared chickweed and shepherd's purse. Quackgrass and Ladino clover spread and multiplied wherever conditions were favorable whether the ground was exposed or not.

VERMONT AGRICULTURAL EXPERIMENT STATION

Title: Cytogenetics and Breeding Investigations with Forage Legumes

Leader: A. Gershoy

Trifolium repens var. giganteum, 4n (8x) = 64. Octoploid Ladino clover.

The mild, open winter of 1948-9 and the extreme, early season drought of 1949, apparently combined to cause severe destruction in both octoploids and standard tetraploids (here called diploids) grown in a source nursery, on heavy clay soil. A comparatively high percentage of octoploid individual plants, set out in 1948 as seedlings, in family lines, failed to survive the dry summer. However, survival was uniformly better on sandy loam. Following late summer and early fall rains the remaining plants of both chromosome constitutions were vigorously leafy and in full flower, but diploids consistently showed more aggressive growth. The best individual plants of the 1948 lines were selected as additional parents for the 4th and 5th polycross nurseries set out in 1949 for progeny testing in 1950; selection was based on aggressive growth and size of leaves. In 1949, first year observations were made in the field on family lines derived from best parents grown in polycross nurseries 2 and 3. As noted in the 1948 report, one of these polycross fields (3) was composed exclusively of growth types showing "gigas" characteristics of mammoth or sub-mammoth leaves, erect, tall and compact growth and variable lateral spread. The other field (2) was made up mainly of plants which exhibited more aggressive lateral spread, leaves of somewhat smaller size and variable compactness of habit. Prior to transplanting seedlings to the field, a primary selection was made in the greenhouse on the basis of large leaf size and tall stature rather than on the basis used in 1948, of small leaf size and rapid lateral spread.

This reversed the procedure of 1948 of selecting in the greenhouse for progeny tests of best parents grown in the first polycross nursery. The 1949 seedling progeny tend to reflect the growth type characteristics of mother parents; nevertheless a considerable variation in the extent of lateral spread was observed at the end of the growing season. The variability in earliness of flowering and abundance of flower heads was especially marked. Small leaf size, early lateral spread, early flowering and abundant flowering generally tend to be associated, but the extent of variation in this respect was considerable. Distribution of size of flower heads and length of flower head stalks seemed to be quite at random in the population. In some 1200 seedlings about 25% were outstanding or very good, 50% were good to fairly good, and 25% poor to worthless. But the population as a whole tended to be late flowering. Progeny testing of best parents in the 4th and 5th polycross nurseries will be made in 1950-51. Beginning in 1950, several sets of entries, composed of bulked seeds of polyploids of selections made in successive years, will be studied in replicate plots. Comparisons with several entries of commercial Ladino clover will be made, for yield, persistence and seed set. Duplicate plots will be under observation in 1950 and successive years, with the cooperation of the Experiment Stations in Pennsylvania and Delaware, to determine adaptability in regions other than Vermont. Small farm trials under conditions of grazing by stock will be initiated in 1950.

Lotus corniculatus var. vulgaris. Broad Leaf Birdsfoot trefoil. Over two dozen large leaved clones, of European origin, grown in replicate, have been under observation in a polycross field. These parents were selected from ten family lines planted in 1948, from open-pollinated, best parents grown in the first polycross nursery. Selection for the second polycross test was made primarily on the basis of potential forage yield. The growth types picked were predominantly late-flowering individuals; early flowering plants, thus far observed, seem to be inferior vegetative types. A progeny test will be made in 1950, using the best parents in the second polycross nursery. Plot trials will be conducted in 1950, using bulked seeds. Yield and persistence, as compared with commercially available empire Lotus, as control, will be studied. A small farm trial will be made in 1950, under conditions of open grazing. Infection by Sclerotinia trifoliorum was noticed in late fall of 1949 and especially in the early, mild winter. But destruction of crowns did not appear so severe as that recorded in autotetraploids of Lotus tenuis.

Lotus tenuis 4n=24. Autotetraploid narrow-leaf Birdsfoot trefoil. Field observations have been made of family lines grown from open pollinated primary autotetraploids. A comparatively large number of plants was recorded which appeared as superior forage types in comparison with parent diploids. Routine, check chromosome counts were made to establish tetraploidy, in seeds obtained by open pollination. Seed set in these was uniformly quite low as compared

with diploids. High susceptibility to destruction by Sclerotinia was observed in the mild, open winter. Sclerotia formation was abundant but apothecia were not found. When enough seed is available, this will be bulked and plots will be seeded for yield and persistence.

Lotus uliginosus 4n=24. Autotetraploid Big Trefoil. Family lines of seedlings, obtained from open pollinated primary autotetraploids, were studied in the field. A fairly high percentage of vigorous, forage type plants was found in these seedlings. As in L. tenuis, routine chromosome counts were made in seeds (seedlings) of open-pollination origin, to verify their tetraploid character. Seed set was low as compared with diploid parents. As observed by other workers, seedling plants transplanted to the open field, survive the winter. When enough seed is available, winter hardiness will be studied in seeded plots. Yield, persistence and resistance to Sclerotinia trifoliorum will also be studied.

WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION

Title: Pasture Fertilization Experiments

Leader: G. G. Pohlman

Field work has been completed and the data for eight years are being summarized on the effect of rate and frequency of phosphate application on yield and quality of pasture herbage. Results show greatest total increase in yield on the plots which received the highest rate of application of phosphate fertilizer.

Title: Maintaining Profitable Stands of Alfalfa

Leader: N. M. Baughman

Soil samples from old alfalfa fields have been taken to attempt to correlate soil conditions with longevity of alfalfa stands. The only relationship noted thus far is that soils with high pH in the lower subsoil usually maintain stands for larger periods than soils which are acid in the subsoil. Four plantings have been made with lime and fertilizer plowed under in addition to normal surface applications. These have not been in long enough for any conclusions.

Title: Cause and Remedy for Red Clover Failure in West Virginia

Leaders: J. G. Leach and E. S. Elliott

A survey of disease and insect damage to red clover has been made. As a result of this study, a fungus disease known as "blackpatch" has been found to greatly reduce seed yields of red clover in the

South Branch Valley area of West Virginia. This disease has been found to destroy the flowers and prevent seed formation. The fungus apparently does not produce spores. The studies have shown that it infects the seed and is seed transmitted. It is favored by humid weather.

The fungus spreads over the leaves and stems, causing patches of black, rotting plant tissue. When it reaches the flower heads the seeds are destroyed unless they have already started to harden. In this case, the fungus penetrates the outer part of the seed coat and remains there until the seed is planted, when it starts to grow and infects the new plant. There is some evidence that this fungus may kill young seedlings and be partly responsible for poor stands.

Studies are in progress to devise an effective method of control.

Title: Selection and Breeding of Red Clover

Leader: Collins Veatch

For several years red clover seed has been secured from growers in the South Branch Valley. Most of these growers save seed from year to year and some have not introduced any seed for a number of years. Some of these selected strains have shown promise in preliminary tests. These are being tested further and compared with named strains in an attempt to find a strain which will be more productive, both for seed and hay, than the strains now on the market.

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